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A STUDY OF ACADEMIC SUCCESS PREDICTOR VARIABLES FOR STUDENTS ENROLLED IN AFIT'S GRADUATE OPERATIONS RESEARCH PROGRAMS

THESIS

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Captain, United States Army

AFIT/ENS/GST/88M-10

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Presented to the Faculty of the School of Engineering

of The Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Operations Research

William N. Prokopyk

Captain, United States Army

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Abstract

The purpose of this study was to examine those measurable factors which contribute to Grade Point Performance in the Air Force Institute of Technology's Graduate Operations Research Programs. Student's undergraduate grades and other performance indicators which could be quantified were submitted to statistical analysis. Regression models were then built to illustrate the relationships between the performance indicators and Graduate Grade Point Average.

Some of the predictors collected for analysis were scores from the Graduate Records Examinations, Undergraduate Grade Point Average, Institution (U.S. Service Academy or Civilian College) and type Degree.

This study showed that Graduate Point Performance cannot be predicted with any great degree of accuracy. There are many factors contributing to human behavior and performance. This research did, however, begin to identify those measurable factors which contribute to the prediction equations which can provide an indication of those variables which contribute to performance. Undergraduate Grade Point Average and the GRE scores proved to be the best indicators of Graduate Grade Point success.

This research paves the way for further analysis into the prediction of performance for AFIT's prospective Operations Research students.

A STUDY OF ACADEMIC SUCCESS PREDICTOR VARIABLES FOR STUDENTS ENROLLED IN AFIT'S GRADUATE OPERATIONS RESEARCH PROGRAMS

I. INTRODUCTION

General Issue

The Air Force and its sister services have an important need to continually educate and train their personnel. The Air Force Institute of Technology's (AFIT) Operational Sciences Department provides the armed services with trained analysts who help commanders make informed decisions affecting the United States' military posture. These technically competent officers are an essential ingredient in the military team required to successfully deter and defeat an enemy on the battlefield.

Specific Problem

A methodology to help choose the best candidates among the Operational Science Departments' many applicants would be a valuable decision tool in the graduate schooling selection process. While an academic success prediction model should not be used as an absolute method to select students, it could be used as a decision aid. Ideally, the methodology presented in this study may help choose between two seemingly equally qualified officers who are vying for a single class position. The United States government invests a great deal of money in every officer selected for graduate

schooling. A few examples are the officer's pay and allowances, costs involved with a movement to and from AFIT, and the expense of school resources (e.g. instructors, classroom maintenance, and computer support). Air University (7:43) estimated that the direct and indirect cost of educating a single operations research student for Fiscal Year 1987 was approximately $132,936.

It is clearly evident that this tremendous investment must pay dividends. A methodology to aid AFIT's Office of Admissions in screening prospective students would therefore prove to enhance the Air Force's investment.

The Courses of Instruction

The Air Force Institute of Technology's Operational Sciences department offers two distinct courses of graduate studies in Operations Research, Graduate Operations in Research (GOR) and Strategic and Tactical Sciences (GST). The GOR program is designed to provide officers with a traditional operations research background, emphasizing mathematics, statistics, and economics analysis skills (6:61-62). The GST program focuses on producing 'military oriented' operations research analysts, concentrating on military operations, statistics, and weapon effects engineering (6:62). Both of these programs lead to Master of Science degrees in Operations Research.

A third program exists within the Operational Sciences department called Graduate Space Operations (GSO). Since

the GSO program is significantly different in intent than the operations research disciplines, it will not be considered in this study. This program leads to a Master of Science degree in Space Operations (6:63-64).

In general, to be considered for admission into either the GST or the GOR programs, the candidate must be a career commissioned officer, possess a minimum of 2.5 undergraduate grade point average (UGPA) on a 4.0 scale, and earn qualifying scores on the quantitative and verbal portions of the GRE (approximately 1000 total) (6:10). However, the department head may waive the UGPA or the GRE minimum requirements based on strong performances in one area that compensates for deficiencies in another (6:11).

AFIT Versus Civilian Schools

Prediction factors which may indicate success or failure of civilians at civilian institutions may not relate to officers attending AFIT. The population of students who attend AFIT are unlike the group of students at civilian universities. Although both sets of students usually select graduate education for career enhancement purposes, the officers selected for graduate schooling at AFIT (tuition free) have significantly different educational motivation than their civilian counterparts.

AFIT is a government owned institution whose mission is to train and educate Air Force and DOD personnel to satisfy Air Force requirements, as directed by Headquarters, USAF.

Therefore, AFIT attempts to tailor its graduate programs to meet the Air Force's educational needs. Most civilians receive schooling at the school and in the discipline of their choice with few repercussions for failure. Failure to graduate from an AFIT program may be career damaging. The other significant difference is that military personnel attend AFIT full time and are expected to devote their entire energy to their studies as these studies considered to be their job. The graduates will be placed into positions within the Department of Defense which have been identified as requiring a particular advanced degree.

Admission Procedures

The decision to admit a student into either program rests with the AFIT Directorate of Admissions. Similar to a civilian institution, AFIT reviews and evaluates prospective students' UGPA, GRE scores, undergraduate discipline, and undergraduate institution. But, unlike academic civilian counterparts, AFMPC also considers OER's and AFSC's in its selection process. An officer must have a good performance record to be allowed to attend graduate schooling.

Since the Air Force is extremely interested in furthering the education of its best officers, considering duty performance (as indicated by OER's) may be appropriate to help compensate for low UGPA or GRE scores. However, Stice (31:391) refutes this view by noting that job performance was totally unrelated to UGPA. Bryden (4:26)

also concluded that 'undergraduate collegiate academic performance as measured by cumulative GPA, is not significantly related to occupational performance'. This study does not attempt to evaluate or quantify OER's or AFSC's as a prediction indicator. OER's are not part of an officer's academic record and therefore are not available for this study or by AFIT admissions branch. Therefore it is important to examine the other factors contributing to graduate success prediction.

There are basically two ways to begin a student's admission consideration process (22). The prospective student requests consideration or an officer is centrally identified by either AFIT or AFMPC as a candidate for graduate schooling. The first and most common procedure is a submission of Air Force Form 90 (Officer Career Objective Statement). This form demonstrates the officer's interest in attending a graduate AFIT program. This request for schooling prompts AFIT admissions to review that individual's transcripts and education records and determine which programs the officer is eligible to attend. This eligibility is then communicated to AFMPC and the prospective student. AFMPC then reviews the officer's service performance, time on current station, career considerations, and whether aeronautically rated officers have met their time in cockpit requirements. If AFMPC

determines that it is appropriate for the officer to attend AFIT, a school date and specific program are established.

The AFSC's of the officers that are admitted to both programs vary tremendously. The AFIT catalog (6:62) recommends several specific specialties for the GST program but does not recommend specialties for the GOR program. In general, an officer may apply for admission to the GOR program and will not be denied attendance because of AFSC. However, AFSC may deny admission to the GST program. The officer's career objectives and future analyst needs of the Air Force are also considered in establishing class quotas.

Research Question

This study attempts to analyze and determine which factors contribute to the prediction of the final GGPA for students enrolled in AFIT's Operations Research disciplines. The final GPA's are compared to the factors discussed and relationships, if any, are determined. This relationship analysis is accomplished by applying regression techniques and examining correlations of variables associated with previous Operations Research students. This regression analysis produces statistical models describing the predictor variables.

The classes included in this study are GOR 1977-87 and GST 1979-87. Demographic information is located in appendix K.

Background

There have been many attempts to predict graduate school performance. The most common measure of performance has been GGPA. However, previous AFIT thesis studies, Keith (18), Humphrey (16), and Woodward (36) have all defined failure as 'a student that does not graduate on time'. These efforts do not make a distinction between a student who completes his requirements after his scheduled graduation or a student that never completes his degree. According to the AFIT Course Catalog (6:40), a student has five calender years after his scheduled graduation to complete all degree requirements. Late thesis completions are the main reason for late graduation. Although timely graduation is certainly every student's primary objective, an officer who graduates late should not be considered an unsuccessful student. There is no indication that a late graduate understands the course material any less than a student who completes his requirements on schedule. Additionally, of the 384 students (Appendix D) considered in this study, only two GST's and seven GOR's (2%) failed to receive a degree. There were seven other students who had voluntarily withdrawn. These students had dropped prior to completing the six academic quarters required by both programs. This study only considers those students who had attended AFIT for at least six quarters, and will confine

itself to the analysis of indicators that will predict GGPA as the measure of graduate success.

Research Objectives

This study examines those factors listed in Appendix A, which attempts to predict graduate success in the Operational Sciences courses of study. To help answer this question the following investigative topics will be addressed:

1. What is the relationship between UGPA and Operations Research GGPA?
2. How important are the GRE scores in predicting GGPA?
3. Is one type of GRE (GRE-Q or GRE-V) score or GRE-T more predictive of graduate success than the other?
4. Can both the GST and the GOR programs be predicted with the same degree of reliability?
5. Does the type of undergraduate degree received affect graduate performance as measured by final GGPA? (i.e. math, engineering, or business)
6. Does the length of time between undergraduate and graduate degrees significantly effect GGPA?
7. Is there a difference in predictability between rated and non-rated officers?
8. Is there a difference in predictability between Air Force officers and other services?
9. Does the undergraduate institution (U.S. Service

Academies versus civilian universities) play a significant role in the prediction factors?

10. Can grades from an undergraduate institution be assigned weights to help equalize undergraduate grades. A rating (Appendix B and E) based on the 'difficulty of entrance' will be assigned to each school. This rating is based on the belief that the better students will tend to gravitate toward the schools with higher admission standards. Therefore the most competitive universities will earn the highest score. This quantified value will be known as the 'Quality of Schools' factor. This study assumes that this factor is linear (i.e. a rating of '2' is twice as good as a rating of '4'.

Scope

This study will address the predictability of GGPA as a function of UGPA, GRE scores, and other previously mentioned factors. The classes GOR77D to GOR87D will be included in the study as well as GST79M to GST87M. This study will not consider motivational effects or military performance as these highly subjective indicators are extremely difficult to quantify and obtain.

II. Literature Review

Previous Prediction Attempts

There are many articles, references and techniques pertaining to GPA success predictors. Statistical regression is a widely used method of analysis for rendering inferences and studying correlations. Regression analysis is an natural choice of methodologies because it is 'the exploration of relationships between two or more variables associated in a non-deterministic manner' (8:423).

Graduate Record Examinations

One of the most universally used factors for graduate success predictors is the GRE. The GRE's main purpose is to demonstrate potential for graduate work. It has two distinct parts. The qualitative portion (GRE-Q) and the verbal section (GRE-V). These two GRE scores may be combined to form a total GRE value (GRE-T) (14). Many studies cite these three factors as the greatest indicators of success in graduate school.

Undergraduate Grade Point Average

In addition to GRE, UGPA is another point of consideration for graduate school admission. Furst (11:650) defines grades as 'a measure of the final status or level of achievement that the student has reached, regardless of the amount of effort expended or the relative degree of progress made'.

Thompson and Kobrak (32) attempted to predict success for a Master of Public Administration program considering UGPA as a predictor variable. They chose to define two measures of success; whether the student actually graduated and final GGPA (32:183). This study also felt that because of grading variations between universities and curriculums, that UGPA as a predictor is probably poor (32:184). Correlations of 0.1427 with GGPA certainly supported this position (32:186).

Thompson and Kobrak discovered only weak correlations between UGPA ($r = 0.1427$), job ranking ($r = 0.0759$), the university's own developed English test (GRE not required by this institution) ($r = 0.3669$), time from undergraduate degree to Master's admission ($r = 0.1999$) and GGPA (32:186). They found that these four predictor variables combined accounted for only 16% of the variance in the logarithmic GGPA. They did, however, discover strong correlations ($0.5708 \leq r \leq 0.62492$) between a students initial performance and final performance in that graduate program (32:187). This finding, although interesting, does not help in predicting GGPA prior to admission.

Quality of Undergraduate Schools

Grades and UGPA vary in meaning due to differences in institutions, professors and subjects. On the average, college students will attend about thirty classes during their undergraduate programs. The grades from these classes

will compose the UGPA. However, this GPA is composed of disparate elements. Different disciplines, universities, and subjects have different grading standards. If these components were equal, UGPA would be a better predictor of GGPA (12:13). These disparities will certainly reduce the correlation between UGPA as a predictor of GGPA.

Another reason for grade inconsistency and unreliability can be described as ' grade inflation' (20:4-5,23). There are many theories accounting for grade inflation. The most common explanation of inflation is when an institution perceives that it is grading its students too severely. That school's grades appear lower than average and seem as though its students are below the natural mean. Therefore in an attempt to correct this impression, the university may 'lower' its grading criteria to make their students appear as if they are earning higher grades to remain competitive with the students of other schools. There is no sure and accepted way of quantifying grading differences. However, if the value of a student's UGPA could be related to the difficulty of the undergraduate institution attended, then perhaps the disparity in grading standards as a predictor could be reduced. The magnitude of difficulty in earning a specific type of degree varies from school to school. Usually, the more prestigious and respected an institution is (20:6,17), the tougher its curriculum, admission standards, and grading criteria.

For example, consider a student who earned a 3.5 UGPA in Electrical Engineering from The Massachusetts Institute of Technology (MIT) versus someone who earned a similar degree and UGPA at a mid-sized public university with less stringent admission standards than MIT. Certainly a graduate school admissions board would tend to regard the MIT student's record as more attractive simply because of that well known university's demanding curriculum and its high admission standards (20:17,23). This study endeavors to compensate for grading disparities by attempting to quantify a 'Quality of Schools' factor. This is be accomplished by consulting a reference profiling American undergraduate universities (1). It is reasonable to assume that admission prerequisites are related to the level of academic difficulty of an institution (e.g. the better high school students will tend to gravitate toward better universities). In support of this concept, a dean of a highly rated graduate university stated that a prospective graduate student's transcript should 'include the mean verbal and quantitative scores of entering freshmen of their college's chosen entrance exam' (20:23). Therefore it is reasonable to conclude that the higher the admission standards of a university, the more difficult it is for students to maintain a high UGPA. Furthermore, a high UGPA at one university may equate to average grades at another.

A method of equalizing grades from different institutions may prove to be valuable in using UGPA as a predictor of GGPA.

There are six subjective levels of university rating, based primarily on admission standards, which are valued from 1 to 6 for use in this study (1). They are defined as follows:

Most competitive ... 1
highly competitive.. 2
very competitive ... 3
competitive 4
less competitive ... 5
non-competitive 6

Each category describes minimum admission standards (Appendix B) for that class of colleges. These standards (1) are based on incoming freshmen as described by high school rank in percentage, high school GPA, and median SAT and ACT scores required for admission.

Additionally, correlations are investigated between United States service academy graduates and GGPA and non-academy graduates.

Other Studies

Correlation is defined as the strength of linear relationship between two variables in a particular sample set (24:418). This study uses the 'Pearson product moment correlation coefficient 'r', whose value is between -1.00 and +1.00' (24:418). If r=1.00 or -1.00, 'all of the points fall exactly on the least squares line' (24:419).

'If r is near or at zero, this indicates 'little or no linear relationship between the observed values' (24:418). Combinations of various predictor variables will produce correlation coefficients greater than any one type of predictor (25:1138) and are necessary for optimum prediction models.

The correlation and significance between predictor factors usually depends on the field of study that is being considered. Omizo and Michael (27:434) have shown that GGPA predictability based on GRE scores varies with the graduate field of study. Correlations between GRE and GGPA have ranged from .08 to as high as 0.47. For example, success prediction for a graduate program in English literature may be more dependent on the GRE-V score than the GRE-Q score. This can be further illustrated by comparing the results of two different prediction studies. One study dealing with graduate performance prediction for counselor education program cites UGPA as the greatest contributor to GGPA (correlation of .38 at .001 level of significance) (27:433) while another study examining an educational psychology program determined that 'UGPA was not significantly related to GGPA' (2:963).

Furthermore, Covert and Chansley (5:947) split 306 Master's of Education students into six sub-groups and did an analysis of their final GGPA. Their results showed 'differential predictability across the different sub-

groups'. This illustrates that even though these students were in the same Master's degree program, variations in the sample populations caused different predictor correlations. Therefore, when considering predictability for a single academic discipline, the variations within the considered population and external factors can cause the independent variables to have different correlations associated with them. This makes identifying the correlation between different prediction values even more difficult.

Broadus and Elmore (3:545-6) determined that the final GGPA's for 257 Library Science students vying for Master of Science degrees, were much more correlated to GRE scores than to UGPA. Their study indicated that correlation was high between GRE-V and GGPA with $r=.35$ ($p<.001$) and GRE-Q versus GGPA at $r=.30$ ($p<.001$). But UGPA only achieved a $r=.23$ ($p<.001$).

However, Herbert and Holmes warn not to use GRE exclusively as a predictor of graduate success (15). Additionally, they report that the Educational Testing Services recommends that '..GRE scores are meant to serve only as a partial indicator of actual academic potential' (15:416). Despite this warning, they found that for 67 Master of Education students, a Spearman rank-difference correlation showed that significant correlation existed between GRE-V and GGPA (15:418).

In addition to GGPA, other academic measures of success have been examined to determine if UGPA and GRE can help predict them. One such example was a study by Kirnan and Geisinger (19) to determine the 'utility of differential prediction of psychological graduate students'. Their study compared UGPA, GRE-V, and GRE-Q versus their ability to predict performance on a Psychology Master's Comprehensive Examination (MACOMP). In this case, only the GRE-V correlated significantly with MACOMP performance at $r = .43$ ($p < .01$) for graduate psychology students (19:817-8). This particular study was unable to correlate UGPA with MACOMP performance. They attributed the lack of correlation to 'undergraduate grade inflation and selection factors' (19:819).

Once again this demonstrates that predictability varies with graduate discipline. It is reasonable to assume that high GRE-V scores would provide a better indicator of success in a graduate English program than it would for a Civil Engineering curriculum.

Another attempt to predict performance (other than GGPA) was a study by Dole and Baggaley (9:423). Their study investigated the validity of GRE and UGPA which contributed to the success measures of scholarship and professionalism for Doctoral Education Programs. Scholarship is defined as the qualities that would make you recommend a person for

employment while professionalism is defined as practical skills required by the profession.

Dole and Baggaley used interpretation based on zero-order correlation rather than multiple regression techniques. They found that their highest correlation with their two performance measures was logarithmic age at the time program entrance (They chose to transform the age in this manner due to the positively skewed age distribution). Surprisingly they found a negative correlation $r=-.45$ ($p<.01$) for scholarship and $r=-.47$ ($p<.01$) for professionalism (9:424-425).

Canonical Correlation

Pristo (29) suggests that cross-validation should be considered when applying statistical techniques to predictive factors. His study (29:929) examined "if canonical correlation could exhibit predictive efficiency regarding graduate program success (GGPA)". Pristo initiated two criteria and eight predictors as two variable sets for analysis. He reported that 38.9% of one set's variance was in common to the other variate. However, the canonical correlation was reduced to a non-significant level by cross-validation (29:929). Pristo's study demonstrates the need to check for multi-correlation between factors which can artificially lower the reliability of a predictor variable.

AFIT Prediction Studies

Keith (18) performed a study to examine success predictors for graduate students in AFIT's department of systems management. Keith (18:41-42) concludes that the ability to actually predict GGPA was at best modest. Furthermore, he concludes that if students from different disciplines were considered together, this would reduce the ability to predict GGPA even further (18:41). This is where indicator variables may prove to become significant. Keith used multiple regression analysis and the evaluation of predictor variables using discriminate analysis (18:17).

Keith's concluded that motivation (AFIT volunteer) or the lack of motivation (non-volunteer) was the single greatest factor to degree receipt or non-receipt (18:42-43). This study does not attempt to quantify motivation factors because these factors are considered to be extremely subjective in nature and, therefore, difficult to quantify.

Another similar AFIT study was performed on Graduate Engineering Management students. Humphrey's efforts showed that the most important characteristics for success prediction were (in order of significance) age, years in military, and time since undergraduate degree (16:92). These factors as easily obtained and therefore are included in this study. Humphrey concluded that GRE-Q and GRE-T scores were linearly related to his defined academic levels of high, middle and low successful profiles (16:98). These

three levels of performance were based on a student's final GGPA. Furthermore, Humphrey's study did not significantly correlate GRE-V scores to final GGPA (16:97). A final interesting observation in Humphrey's study was that the average time in the military for unsuccessful students (late or non-graduation) was 10.25 years while the successful (timely graduation) students averaged only 6.80 years (16:84).

Van Scotter's (34:38) research efforts examined predictor variables for 17 separate AFIT Master Degree programs between the years of 1977 and 1982 inclusively. Van Scotter combined 15 of these programs into 5 statistically similar groups based on coinciding predictor/criterion relationships (34:46). He reported that these grouped programs 'reduced the effects of small sample instability without significant predictor/criterion degradation' (34:47). The programs within Van Scotter's groups showed no particular reason for their correlations with the predictor variables. For example, it would be reasonable to expect that the GRE-Q would yield a greater correlation with the GGPA of mathematical intensive programs like Aeronautical Engineering, Physics and Operations Research (group #4) than with Logistics, Engineering, Contracting, and Acquisition Management programs (group #3). However, group #4's GRE-Q correlation value with GGPA was higher ($r = 0.374$) than group #3's ($r = 0.312$) (34:96-97).

Van Scotter concluded that GRE scores, GMAT scores and UGPA served as valid predictors for only six of the programs examined and indicator variables (years of commissioned military service) only improved two group's prediction accuracy (34:71). The GST (34:64) program was included in one of these groups. He also found that (Pearson) predictor correlations varied significantly from program to program (34:70). Van Scotter's groups showed no apparent reason for the disparities in correlation between the programs. For example, it would be reasonable to expect that the GRE-Q would yield a greater correlation with the GGPA of mathematical intensive programs like Aeronautical Engineering, Physics and Operations Research (group #4) than with Logistics Management, Engineering Management, Contracting Management, and Acquisition Management programs (group #3). Group #4's GRE-Q correlation with GGPA was r = 0.374 as compared to group #3's r of 0.312 (34:96-97). These findings support the viewpoint that different disciplines will produce unique predictor relationships. Those factors which may contribute to a good undergraduate performance in a particular field (i.e. mathematics) will not necessarily help that same student perform equally well in music or business related disciplines.

Woodward's (36) thesis efforts parallel Van Scotter's. His 1987 research of various resident Master's programs supported Van Scotter's 1983 findings. He found a

correlation of 0.545 between GMAT verbal and GGPA and 0.465 between GMAT and GGPA across the 908 Master's students attending AFIT from 1984 to 1986 (36:19,31). GRE-T scores produced a 0.306 correlation (36:31). This high GMAT correlation is interesting, but of no use in this study because prospective AFIT Engineer students are not required to take this examination.

Summary

The literature reviewed showed that predictor results and correlations vary between disciplines examined, populations considered, and assumptions. This is to be expected as these factors make each situation unique, and requiring a comprehensive examination to determine its best method of prediction. UGPA and GRE scores are the most commonly used predictor variables. In general, the predictors do not yield extremely high correlation factors.

III. METHODOLOGY

Introduction

This chapter discusses the methodology used to attempt to develop and predict relationships, if they exist between GRE scores, UGPA, and GGPA. These relationships were examined using multiple regression techniques available with the SAS software system for data analysis.

Sub-Objectives

To satisfy the primary research objective, the following tasks were undertaken:

1. Data Collection

-- Student's grades for past GST and GOR classes were transposed to AFIT'S VAX/VMS computer system into usable data bases (see appendix C).

-- The appropriate student variables were selected.

-- Data were logically arranged within data files for easy access for analysis.

2. Statistical Methodology

-- Stepwise multiple regression and Pearson's Correlation coefficients are the methods chosen for the conduct of this study.

3. Analysis

-- Determine the correlations between input factors and GGPA.

-- Ascertain the regression equations which best fit the data.

-- Perform residual analysis.

4. Results

--Translate analysis into understandable language and list statistical models.

--Support and discuss conclusions.

Sample Population

Data were collected from students' academic records located at AFIT registrar's office, at Wright-Patterson AFB, Dayton, Ohio during the month of December, 1987. The information was transferred by hand to collection sheets and then loaded into AFIT VMS/VAX computer system (Appendix C).

The sample set includes all of the students who attended GOR classes from 1977 to 1987 and GST classes 1979 to 1987. There are 202 GOR and 182 GST data sets for a total of n = 384.

In the event that some data were missing (e.g. GRE scores) the average score (Appendix H) for that particular population was entered to fill the gap.

Indicator Variables

Success prediction formulas for most civilian graduate universities consider UGPA and GRE scores (20:21). In addition to applying regression techniques to predict AFIT operations research GGPA as a function of UGPA and GRE

(quantitative variables), the effect of indicator variables (qualitative) was also examined (26:417). These indicator variables '...examine the equality of different regression equations' (26:344). Combining these two types of predictor variables, it is possible to develop linear regression functions which better describe the appropriate relationship between the predictor variables and GGPA in the form of:

$$GGPA = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_n X_{in} + \varepsilon \qquad (1)$$

where

GGPA = dependent variable
β_0, β_i = parameters
X_i = independent predictor variables
ε = random error terms $N(0,\sigma)$
$i = 1,\ldots,n$

These general regression models comprise linear 'first-order' models because none of the parameters have exponents greater than one and there are *no* interaction terms (26:31). Several squared terms (UGPA, GRE scores, age, etc.) were considered but failed to improve the models' predictability. Interaction action terms (UGPA*GRE scores, UGPA*Time since degree, UGPA*Age, etc.) were also attempted with similar results.

Nineteen variables (appendix A) were considered in the analysis. In addition to UGPA and GRE, it would be reasonable to assume that other factors may contribute to a student's overall GGPA performance. For example, the type of undergraduate degree the student possesses may help him or her achieve a higher success level. Of the 384 students

considered in the study, only 17 of these students earned a perfect GGPA of 4.0. It is interesting to note that 13 of the 17 students were mathematics undergraduate majors. This might indicate that a mathematics background proves to be the best undergraduate preparation for Operations Research studies.

When an indicator variable has more than just a 0 or 1 value an alternative is to employ what is referred to as an 'allocated code' (26:351). This assumes that all levels of the indicator variable were equal. For example, a value of '6' would be considered 3 times as great as a value of '2'. An assumption of this study is that the indicator variables with more than one value follow the equal magnitude concept. Note that the Quality of Schools, type of undergraduate degree, rank, etc. predictor variables are therefore treated as quantitative (real) variables (more than one level) but are actually qualitative in nature (26:339).

The predictor (independent) variables (Appendix A) considered in the analysis of the GOR and GST programs are as follows:

1. GRE: The Graduate Records Examination (GRE) is divided into two parts consisting of the Verbal and Quantitative portions respectfully. The GRE is not intended to be an intelligence or an aptitude test. It is designed to provide graduate schools an indication of a student's general scholastic ability (13:4). These are different

concepts. The Verbal section of the test measures the students ability to comprehend and reason with word problems. 'The GRE-V is broken down into four question types: analogies, antonyms, sentence completions, and reading comprehension sets' (28:6). The remaining part of the basic examination is the GRE-Q whose purpose is intended 'to measure basic mathematical skills, concepts, and the ability to reason quantitatively and to solve problems in a quantitative setting' (28:10). This study also considers the sum total (GRE-T) of the Verbal and Quantitative portions as a possible predictor variable for GGPA.

In addition to the GRE-V, GRE-Q and the GRE-T, students will often take the Analytical portion of the general GRE test. This test is not required by AFIT and therefore not always reported in the scholastic records. The GRE-A 'measures the ability to understand a given structure of arbitrary relationships among persons, things, or events (28:16). This description can easily refer to an Operations Research person's problem solving thought process. The GRE-A was considered when available.

2. UGPA: The student's undergraduate grade point average. All grades are listed on a 4.0 scale. Those grades not in this format were converted.

3. Military Rank: The rank at the time of the student's admission into their respective program.

4. Time in the Military: The amount of years a student had served in the military at the time of admission. This factor is highly correlated with rank.

5. Time since Undergraduate Degree: The length of time (in years) between receipt of the undergraduate degree and admission into AFIT.

6. Age: The student's age in years at the time of admission into AFIT.

7. Sex: The student's sex.

8. Previous Graduate Degree: This variable indicated whether the student held a Master's degree at the time of admission into AFIT.

10. Undergraduate Degree: The type of undergraduate degree considered by AFIT as the basis of admission into one of the Operations Research programs.

11. Marital Status: This indicator variable lists whether a student is married or not married.

12. Student Code: Student code signifies a student's branch of service.

13. Flight Status: This code indicates an officer's aeronautical rating. There is no distinction in this study between pilots and navigators.

14. AFIT Program: This variable differentiates students enrolled in the GOR program from those in the GST course of study.

15. Academy Graduate: This data base listing distinguishes U.S. Service Academy (Army, Air Force, and Navy) graduates from those who obtained their undergraduate degrees at civilian universities.

16. Quality of Schools: The 'Quality of Schools' factor (1) is a numerical score assigned to an undergraduate university. This rating is based on the institution at which the undergraduate degree was actually earned.

Division of Data

For purposes of analysis, the data was grouped in three basic ways: The GOR's and the GST's separate, and both groups together. These three data sets were further grouped into U.S. Military Service Academy graduates (Army, Air Force, and Navy) and civilian school graduates.

Finally, both groups combined were divided into sub-groups based on final GGPA. This division was defined as 'success levels' and is similar to Humphrey's (16:46) different degrees of success profiles. Success level 1 (S1) is a student who achieved a GGPA between 4.00 and 3.67. Success level 2 (S2) is a final GGPA of 3.66 to 3.33 and success level 3 (S3) is 3.33 and below respectively. The intent is to determine if a relationship exists within the three separate success levels. These divisions of data produced 12 prediction models (tables 3 through 14).

Categories of division and specific groups are listed in table 1. There are six categories and three groups

equaling a total of 18 sub-groups. Prediction models for the three defined success levels of the separate programs were not included in this study although (r) correlations of GGPA to UGPA and GRE scores are listed in table 2.

Table 1
Division of Data

	ALL	ACADEMY GRADUATES	CIVILIAN GRADUATES	4.0-3.66 S1*	3.65-3.33 S2*	3.32 & BELOW S3*
GST	182	89	93	*70 (39%)*	82 (45%)	30 (16%)
GOR	202	74	128	91 (45%)	76 (38%)	35 (17%)
BOTH	384	163	221	161	158	65

* S level is defined as the level GGPA success, e.g. S1 is the highest level, S2 is next higher, etc.
* The percentages refer to the percent of the class that fell into each respective success category.

Stepwise Multiple Regression

Stepwise multiple regression proved to be the best single regression method. This procedure considers each predictor's weight in direct proportion to its effect on GGPA and in inverse proportion to the other predictor variables. The predictor variable with the greatest correlation with the dependent variable is the first one included in the regression model. This procedure considers predictor variables, one by one, in order of their ability to reduce the variance of the dependent variable (21:400).

The proportionate reduction of total variation in the response variable (26:241) is defined as the coefficient of multiple determination and is denoted by:

$$\text{R-Square } (R^2) = 1 - \frac{SSE}{SSTO} \qquad (2)$$

where

SSE = Error sum of squares
SSTO = Total sum of squares

Stepwise regression technique starts by performing separate simple regressions for each variable. The procedure determines which single factor produces the greatest effect on the dependent variable. The predictor variable with the greatest correlation with the dependent variable is the first one included in the regression model. Next, the technique checks all of the remaining constituents, adding the next most variance reducing variable to the first one, thus creating a two factor subset. Mallows C(P), a comparative statistic (10), was developed for each model. This statistic is defined as follows:

$$C(P) = \frac{SSE\ (P)}{MSE} - (n - 2P) \qquad (3)$$

where

n = Number of predictor variables
P = Number of variables in the model
SSE = Error sum of squares
MSE = Mean square error for model considering all variables

The analysis continues until all the variables are entered into the model or are dismissed as not producing the specified 'minimal residual sum of squares (or largest increase in R^2)' (10:82). The criterion for adding a

variable is defined by the 'error sum of squares reduction, coefficient of partial correlation, or F statistic' (26:430).

The search algorithm for stepwise regression fits a simple linear model and then tests the F* statistic, checking if the slope is zero (26:430):

$$F^* = \frac{MSR\ (variable)}{MSE\ (variable)} \qquad (4)$$

where

MSR = Mean square root (unbiased estimator of variance)
MSE = Mean square error

Stepwise regression considers the predictor variable with the largest associated F*factor first.

The process continues until the procedure determines that no variables exist which will provide reduction of variance within the pre-established criteria. The R^2 factor continues to increase with the addition of predictor variables regardless of the newly added variable's ability to contribute information regarding the variance in the dependent variable. Therefore a large R^2 does not necessarily mean that the model describing the response is the best fit (26:241).

It is important to establish a criteria limiting the addition variables into the model. This limiting criteria (33:5) is defined as the S(P) 'factor'. The smallest S(P) factor indicates which random predictor variable mix provides optimum contribution to the model's ability to

predict GGPA while simultaneously reducing the variance. S(P) thus allows easy identification of the best model.

Residual Analysis

The validity of the models was tested by evaluating the variance of the residuals (30:29). 'Residuals are highly useful for examining the aptness of the analysis of variance model for a given application' (26:531). Since the upper limit of the dependent variable (GGPA) is constrained by 4.00, the variance of the predictor variables becomes smaller as this limit is approached. This unequal variance is defined as heteroscedasticity disturbance (17:214-219). A technique (23) to compensate for this effect is to logarithmically transform the dependent variable and add a correction factor 'δ'. The transform of GGPA was accomplished as follows:

$$GGPA = -(LOGARITHM(4.0 - GGPA + \delta) \quad (5)$$

This transformation allows statistical testing of the first and second moments specification (35:817-838;10:47) to determine if the unequal variances have significantly affected the regression model. The actual 'δ' is a trial and error procedure which equally distributes the variances throughout the model. Various different 'δ's' were tried (0.001 through 0.5) until a 'δ' of 0.1 produced what appears to be a equal variances among the independent variables.

The transformed data with equalized variance produced a slightly higher R^2 for the GOR's and GST's (0.2593 versus

0.2297) than the non-transformed data but a lower chi-square value (11748.6 versus 12847.2). Since the large Chi-square value was of equal magnitude there was no significant advantage to logarithmic transformation.

Summary

This chapter presented the methodology used to evaluate the various predictors of GGPA. Stepwise regression techniques were deemed the most appropriate method of analysis and a method for limiting addition of variables (S(P) factor) to the regression model was discussed. Residual analysis was also performed.

The results of this study are discussed in chapter four.

IV. FINDINGS AND ANALYSIS

Introduction

This chapter discusses the results of the statistical analysis.

Correlation Results

The combined group of GOR's and GST's (n = 384) were checked for correlation (r factor) with GGPA. The highest correlation noted for this combined group was that of 0.30220 for UGPA and 0.32165 for GRE-Q. Table 2 is a list of correlations (GGPA versus UGPA and GRE scores) for the three success levels. A full Pearson correlation matrix is listed in Appendix F.

TABLE 2

Correlation coefficients

	GRE-V	GRE-Q	GRE-T	GRE-A	UGPA
ALL	0.10860	0.32165	0.25697	0.25793	0.30220
GOR	0.02518	0.32397	0.20540	0.35448	0.26241
GST	0.21964	0.31665	0.33134	0.12000	0.35730
ALLS1	0.07480	0.20026	0.16161	0.17115	0.35122
ALLS2	0.05539	0.15537	0.12801	0.20223	0.14927
ALLS3	-0.04936	0.19546	0.07674	0.09975	-0.14740
GORS1	0.21531	0.21829	0.25099	0.31447	0.31057
GORS2	-0.05029	0.17622	0.08288	0.31543	0.01040
GORS3	-0.13695	0.29126	0.10573	0.24896	-0.09106
GSTS1	-0.06430	0.17867	0.08044	-0.10293	0.39055
GSTS2	0.15842	0.13401	0.17601	0.12779	0.22644
GSTS3	0.08051	0.04033	0.08328	-0.09011	-0.05716

Regression Results

The stepwise regression procedure produced several interesting models (tables 3 through 14). The top portion of the tables present the regression equation and associated data. The lower part depicts the R^2 and the S(P) factor for various combinations of the predictor variables. The lowest S(P) value indicated which subset of variables produced the optimal equation. Appendix G provides a summary of the regression equations.

The first data set treated to regression analysis was the combined set of GOR's and the GST's. This first set (table 3) produced a model with a R^2 of 0.22967586 and a 'F' value of 13.98 and included 8 variables at the 0.500 significance level. The single strongest predictor was UGPA with a 'β' value of 0.18795536 and a single 'F' factor of 32.07. GGPA as a function of the predictor UGPA is plotted in Appendix I. It is interesting to note that some low UGPA values correspond to relative high GGPA's. In other words, none of the students with incoming UGPA's below 2.8 finished with a GGPA below 3.0. Also there are seven outlying UGPA's below 2.4 which coincide to GGPA's above 3.3. This seems to imply that the students with low incoming UGPA's were determined to overcome undergraduate deficiencies and tried harder to succeed.

GRE-Q and GRE-A were also predominant in the combined GOR and GST model with 'F' values of 16.27 and 6.29

respectively. The most significant indicator variables were the 'Quality of Schools' factor (QS) and Previous Graduate Degree (PG) recipients (see table 3). The S(P) criteria portion shows that the predictor variables GRE-Q, UGPA, GRE-A, Previous Graduate Degree, 'Quality of Schools' factor and to a lesser extent Undergraduate Institution (IN) were continually considered as the first six variables in the eight variable regression model.

The GOR and GST classes were separated and autonomous models were calculated. The GOR class (table 4) also provided an 8 variable model with a combined R^2 factor of 0.30624043 and 'F' of 10.65. As with the case of the two classes together, UGPA was the strongest indicator with a 'F' value of 17.01. GRE-T entered the equation, along with GRE-A ('F' = 13.62) and GRE-Q ('F' = 6.60) as contributors to the optimum model although their 'B' values were not that high. The most significant indicator variable was once again Previous Graduate Degree with a 'F' value of 8.89. Similar to the combined model, the S(P) criteria shows that of the eight variable GOR regression model, six were constantly considered in the same variance reducing order. Of these six variables, four of them were the same factors as the combined model.

The GST class model (table 5) did not include GRE-A as did GOR and both classes combined, but did contain GRE-T and GRE-Q. Its model contained 6 predictor variables and

finished with an overall R^2 of 0.25390263 and a slightly lower 'F' value than the GOR's of 10.65. Once again, UGPA had the single highest 'F' value of 21.10. The indicator variables were Time Since Undergraduate Degree (TD), Previous Graduate Degree, and Marital Status (MS). Surprisingly, the variable with the next highest 'F' value was Marital Status (although negatively correlated). This meant that the prediction for a single student was a lower GGPA than for a married student. The S(P) criteria in this case showed that of the GST's six variable model, only two (UGPA and Marital Status) were incessantly entering the model. GRE-Q and GRE-T fluxed as one of the other variables.

Next, the U.S. Air Force and U.S. Military Service Academy graduates were examined. Academy graduates for both programs (table 6) produced a 4 variable model with a R^2 of 0.28870451 and a combined 'F' value of 16.03. As with the previous models, UGPA had the single greatest effect on GGPA with a 'F' value of 22.11. GRE-Q was included (F = 13.76) as were Type of Undergraduate Degree and Marital Status. These 3 Academy graduate models yield the highest correlation for predictor variables. This is to be expected since the academies have a much more structured grading policy and consistent education procedures than the pool of all civilian universities. Its S(P) criteria showed that three of the four variables (GRE-U, GRE-Q, and Type of

Undergraduate Degree) comprising the optimal model, were perpetually considered for their variance reduction.

An analysis of GOR academy graduates (table 7) propagated a 5 variable model with a R^2 of 0.30580409 and a combined 'F' of only 5.99. GRE-A was the single best predictor (F = 12.59) while UGPA produced an 'F' value of 4.04. For the first time, GRE-V entered a model (F = 2.26) while the indicator variables were once again Previous Undergraduate Degree and Type of Undergraduate Degree. The S(P) analysis showed that of the Academy graduate GOR's five variable model, only two continually repeated, and that only Type of Undergraduate Degree paralleled the combined Academy graduate model.

GST Academy graduates (table 8) produced a 5 variable model with the highest R^2 value of any model at 0.42664654 with a combined 'F' value of 12.35. UGPA was once again the single most significant predictor with a 'F' of 28.43. GRE-Q (F = 7.17) and marital status (F = 10.14) continued to be a part of the models, but for the first time Aeronautical Rating (AR) and Student Code (SC) were significant enough to be included. All three indicator variables were negatively correlated. Unlike the previous model, the GST Academy's S(P) criteria produced virtually four repeating variables (UGPA, GRE-Q, Marital Status, and Student Code). The UGPA and GRE-Q were the same in the combined Academy graduate model.

Table 9 shows the results of examining the entire population of non-academy graduates. The analysis of these civilian schools graduates yielded a 5 variable predictor model. The combined R^2 was low at 0.20072356 with a 'F' value of 10.80. UGPA was the most significant ingredient (F = 16.73). GRE-Q (F = 6.25) and GRE-A (F = 4.89) were also included in the model. Quality of Schools at a 'F' of 5.26 were surprisingly negatively correlated. Rank (RK) entered the regression model for the first time at a 'F' value of 4.71. This model had four repeating variables (GRE-Q, UGPA, Quality of Schools) in its S(P) variance reducing criteria.

GOR civilian graduates (table 10) removed from the total non-academy population showed an increase in R^2 to 0.27556740 but a slight decrease in fit (F = 9.28). This model also contained 5 variables with UGPA as the most significant (F = 13.77). GRE-A (F = 4.90) and GRE-Q (F = 3.36) remained in the model but the two indicator variables changed to Previous Graduate Degree with a 'F' of 6.79 and Student Code with a 'F' of 6.06. This model's S(P) criteria showed that of its four significant repeating variables (GRE-A, UGPA, Student Code, and Previous Graduate Degree), UGPA and GRE-A were also found in the combined civilian graduates' regression model.

GST civilian graduates (table 11) also contained a slightly higher R^2 (0.25657750) and a decrease in total 'F' of 7.59, than did the total non-academy graduate population.

However, instead of UGPA (F = 9.84), this 4 variable model indicated that GRE-T was slightly more significant at a 'F' of 13.25. The variable indicators were Type of Undergraduate Degree and Aeronautical Rating. Both of these provided extremely small values for 'F'. The S(P) criteria shows that Time in Military and UGPA were the only two variables constantly considered by the procedure.

The classes were separated by final GGPA success levels (S1 = 4.00 to 3.67, S2 = 3.66 to 3.33, S3 = 3.32 and below). It was hoped that by combining students with similar final GGPA, another and perhaps more predictable model could be achieved.

Analysis of success level 1 (S1) provided a 4 variable model with a small R^2 of 0.18237167 and a 'F' value of 8.64. As with previous models, UGPA was the single most significant predictor variable (F = 19.32) followed by GRE-Q (F = 4.50). The indicator variables were Quality of Schools and Undergraduate Institution. The S(P) factor reported that UGPA, GRE-Q and Type of Institution continually contributed to the optimal model selection.

Success level 2 (S2) (table 14) proved to have a diminutive R^2 of 0.05932163 with a small combined 'F' value of 4.89. This regression only provided a 2 variable model containing GRE-A (F = 6.10) and UGPA (F = 3.04). This was the least significant model. Only GRE-A was continually considered by the S(P) factor.

Success level 3 (S3) (table 15) produced a 3 variable model with a R^2 of 0.20531082 and a 'F' of 5.25. Interestingly, the model contained only indicator variables. They were Time in Military (TM), Undergraduate Institution, and age. These variables had associated 'F' values of 8.18, 6.13, and 5.59 respectively. Time in Military was the only variable constantly considered by the S(P) criteria.

The models derived from dividing the population by final GGPA provided such small correlations that no further attempt to secure regression equations by program success level was attempted.

Predictor Models

The following pages contain the prediction models discussed in this chapter. For convenience, the following is a list of the predictor variable abbreviations used in the tables:

V	=	GRE-V
A	=	GRE-A
Q	=	GRE-Q
T	=	GRE-T
U	=	UGPA
RK	=	RANK
TD	=	TIME SINCE DEGREE
TM	=	TIME IN MILITARY
PG	=	PREVIOUS GRADUATE DEGREE
MS	=	MARITAL STATUS
SC	=	STUDENT CODE
AR	=	AERONAUTICAL STATUS
DEG	=	TYPE OF UNDERGRADUATE DEGREE
QS	=	QUALITY OF SCHOOLS
IN	=	CIVILIAN INSTITUTION OR ACADEMY

Table 3

BEST MODEL FOR GOR's and GST's COMBINED

R SQUARE = 0.22967586 C(P) = 4.90150325

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	6.11874081	0.76484260	13.98	0.0001
ERROR	375	20.52202560	0.05472540		
TOTAL	383	26.64076641			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.28814680				
Q	0.00082935	0.00020559	0.89056267	16.27	0.0001
A	0.00053634	0.00021385	0.34422988	6.29	0.0126
U	0.18795536	0.03318856	1.75517955	32.07	0.0001
PG	0.08079898	0.03010723	0.39414781	7.20	0.0076
DEG	-0.01583262	0.01053606	0.12357715	2.26	0.1338
MS	-0.04828857	0.02941547	0.14747764	2.69	0.1015
IN	-0.08374610	0.05599735	0.12240051	2.24	0.1356
QS	-0.04406252	0.01652294	0.38918212	7.11	0.0080

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
8	0.2278848	0.0001467	Q U A PG QS IN TM V
8	0.2279021	0.0001467	Q U A PG QS IN MS T
8	0.2279362	0.0001467	Q U A PG QS IN TD T
8	0.2279886	0.0001466	Q U A PG QS IN RK T
8	0.2280436	0.0001466	Q U A PG QS DEG TD MS
8	0.2280473	0.0001466	Q U A PG QS DEG SC AR
8	0.2280681	0.0001466	Q U A PG QS DEG TM SC
8	0.2281376	0.0001466	U A PG QS T V DEG TD
8	0.2282695	0.0001466	Q U A PG QS DEG RK V
8	0.2283382	0.0001466	Q U A PG QS IN MS V
8	0.2284894	0.0001465	Q U A PG QS IN DEG AGE
8	0.2285840	0.0001465	Q U A PG QS IN RK V
8	0.2286212	0.0001465	Q U A PG QS IN TD V
8	0.2287857	0.0001465	Q U A PG QS DEG TD V
8	0.2289911	0.0001465	Q U A PG QS IN DEG TM
8	0.2290078	0.0001465	Q U A PG QS IN DEG TD
8	0.2292583	0.0001464	Q U A PG QS IN DEG RK
8	0.2296759	0.0001463	Q U A PG QS IN MS DEG

Table 4

BEST MODEL FOR GOR's

R SQUARE = 0.30624043 C(P) = 2.16987405

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	4.81784422	0.60223053	10.65	0.0001
ERROR	193	10.91438350	0.05655121		
TOTAL	201	15.73222772			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.26360662				
U	0.19788214	0.04789393	0.96537094	17.07	0.0001
Q	0.00109840	0.00042745	0.37342515	6.60	0.0109
T	-0.00047072	0.00024930	0.20161895	3.57	0.0605
A	0.00112562	0.00030499	0.77027659	13.62	0.0003
PG	0.16597944	0.05539757	0.50765556	8.98	0.0031
DEG	-0.03974217	0.01618035	0.34116864	6.03	0.0149
SC	0.14200377	0.06477364	0.27179723	4.81	0.0296
QS	-0.03685455	0.01091455	0.64478137	11.40	0.0009

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
8	0.29279665	0.00030025	A U IN PG DEG SC Q T
8	0.29347142	0.00029996	A U QS PG DEG SC Q S
8	0.29358421	0.00029991	A U QS PG DEG SC Q IN
8	0.29358663	0.00029991	A U QS PG DEG SC Q AR
8	0.29368217	0.00029987	A U QS PG DEG SC Q AGE
8	0.29370761	0.00029986	A U QS PG DEG SC Q TD
8	0.29374899	0.00029984	A U QS PG DEG SC V RK
8	0.29393919	0.00029976	A U QS PG DEG SC Q TM
8	0.29402527	0.00029972	A U QS PG DEG SC V MS
8	0.29421249	0.00029964	A U QS PG DEG V T RK
8	0.29447031	0.00029953	A U QS PG DEG V Q RK
8	0.29468480	0.00029944	A U QS PG DEG Q T RK
8	0.29512766	0.00029926	A U QS PG DEG SC Q RK
8	0.29518578	0.00029923	A U QS PG DEG SC Q MS
8	0.30578526	0.00029473	A U QS PG DEG SC V T
8	0.30605274	0.00029462	A U QS PG DEG SC Q V
8	0.30624043	0.00029454	A U QS PG DEG SC Q T

Table 5

BEST MODEL FOR GST'S

R SQUARE = 0.25390263 C(P) = 2.49768391

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	2.75495362	0.45915894	9.93	0.0001
ERROR	175	8.09547990	0.04625889		
TOTAL	181	10.85043352			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.03249403				
U	0.21424465	0.04664341	0.97599692	21.10	0.0001
Q	0.00074854	0.00039532	0.16586107	3.59	0.0599
T	0.00024338	0.00020105	0.06779133	1.47	0.2277
TD	0.00776757	0.00618652	0.07292598	1.58	0.2109
PG	0.04135680	0.03424937	0.06745173	1.46	0.2289
MS	-0.10752851	0.04853739	0.22703816	4.91	0.0280

S(P) CRITERIA

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
6	0.25244594	0.00026638	U Q MS AGE T AR
6	0.25261838	0.00026632	U Q MS TD T AR
6	0.25273742	0.00026628	U Q MS AGE T SC
6	0.25286896	0.00026623	U T MS V AGE AR
6	0.25290702	0.00026622	U Q MS TD T SC
6	0.25318511	0.00026612	U T MS V TD AR
6	0.25379616	0.00026590	U Q MS TD PG AR
6	0.25389071	0.00026587	U T MS V TD PG
6	0.25390263	0.00026586	U Q MS TD T PG
6	0.25399613	0.00026583	U T MS V AGE PG
6	0.25407476	0.00026580	U T MS V AGE SC
6	0.25407715	0.00026580	U Q MS AGE PG AR
6	0.25416903	0.00026577	U Q MS AGE PG T
6	0.25439884	0.00026568	U T MS V TD SC
6	0.25571854	0.00026521	U Q MS PG AR V
6	0.25701728	0.00026475	U T MS V PG AR
6	0.25802267	0.00026439	U Q MS PG AR T

Table 6

BEST MODEL FOR ACADEMY GRADUATES (GOR's & GST's COMBINED)

R SQUARE = 0.28870451 C(P) = 0.53741648

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	2.55471008	0.63867752	16.03	0.0001
ERROR	158	6.29416476	0.03983649		
TOTAL	162	8.84887485			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.36104478				
U	0.22963777	0.04883448	0.88087567	22.11	0.0001
Q	0.00094919	0.00025592	0.54799075	13.76	0.0003
DEG	-0.03236811	0.01133795	0.32467323	8.15	0.0049
MS	-0.07179612	0.03939926	0.13228389	3.32	0.0703

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
4	0.27527130	0.00025853	U Q DEG T
4	0.27527139	0.00025853	U Q DEG V
4	0.27527214	0.00025853	U DEG T V
4	0.27559350	0.00025841	U Q DEG SC
4	0.27725669	0.00025782	U Q DEG S
4	0.27820512	0.00025748	U Q DEG AGE
4	0.27980683	0.00025691	U Q DEG TM
4	0.27990703	0.00025687	U Q DEG TD
4	0.28219451	0.00025606	U Q DEG A
4	0.28271884	0.00025587	U Q DEG PG
4	0.28870451	0.00025374	U Q DEG MS

Table 7

BEST MODEL FOR GOR ACADEMY GRADUATES

R SQUARE = 0.30580409 C(P) = 2.87737455

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	1.12497265	0.22499453	5.99	0.0001
ERROR	68	2.55376384	0.03755535		
TOTAL	73	3.67873649			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.50938238				
U	0.14040595	0.06984513	0.15176463	4.04	0.0484
V	-0.00053505	0.00035516	0.08475552	2.26	0.1377
A	0.00173613	0.00048927	0.47286981	12.59	0.0007
PG	0.16933433	0.07941817	0.17073483	4.55	0.0366
DEG	-0.04028519	0.01708650	0.20876450	5.56	0.0213

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
5	0.28326064	0 00057873	A DEG PG Q V
5	0.28326064	0.00057873	A DEG PG V T
5	0.28369588	0.00057838	A DEG PG U AR
5	0.28372740	0.00057835	A DEG U AGE TM
5	0.28372740	0.00057835	A DEG U AGE TD
5	0.28494877	0.00057737	A DEG PG U T
5	0.28650636	0.00057611	A DEG U AGE Q
5	0.28786219	0.00057501	A DEG PG U S
5	0.28933306	0.00057383	A DEG PG U MS
5	0.28941247	0.00057376	A DEG PG U TM
5	0.28941247	0.00057376	A DEG PG U TD
5	0.29140015	0.00057216	A DEG PG U SC
5	0.29265615	0.00057114	A DEG U AGE V
5	0.29464576	0.00056954	A DEG PG U Q
5	0.29655684	0.00056799	A DEG PG U AGE
5	0.29709357	0.00056756	A DEG U AGE RK
5	0.30580409	0.00056053	A DEG PG U V

Table 8

BEST MODEL FOR GST ACADEMY GRADUATES

R SQUARE = 0.42664654 C(P) = 2.13415453

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	2.12871506	0.42574301	12.35	0.0001
ERROR	83	2.86069618	0.03446622		
TOTAL	88	4.98941124			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.03348224				
U	0.34325295	0.06437171	0.98001360	28.43	0.0001
Q	0.00084196	0.00031453	0.24697770	7.17	0.0090
MS	-0.20976385	0.06587226	0.34950217	10.14	0.0020
SC	-0.20159634	0.07199464	0.27024558	7.84	0.0064
AR	-0.07136904	0.04909340	0.07283951	2.11	0.1498

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
5	0.39148891	0.00044609	U SC MS T AR
5	0.39303725	0.00044496	U SC MS T DEG
5	0.39543902	0.00044320	U Q MS DEG PG
5	0.41204773	0.00043102	U Q MS SC S
5	0.41204773	0.00043102	U Q MS SC IN
5	0.41204773	0.00043102	U Q MS SC QS
5	0.41218107	0.00043092	U Q MS SC TM
5	0.41222011	0.00043090	U Q MS SC TD
5	0.41226955	0.00043086	U Q MS SC AGE
5	0.41504377	0.00042883	U SC MS T V
5	0.41504377	0.00042883	U Q MS SC V
5	0.41504377	0.00042883	U Q MS SC T
5	0.41530008	0.00042864	U Q MS SC RK
5	0.41574096	0.00042831	U Q MS SC PG
5	0.41826378	0.00042647	U Q MS SC A
5	0.42187618	0.00042382	U Q MS SC DEG
5	0.42664654	0.00042032	U Q MS SC AR

Table 9

BEST MODEL FOR CIVILIAN SCHOOL GRADUATES (GOR & GST COMBINED)

R SQUARE = 0.20072356 C(P) = -0.55161890

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	3.55215385	0.71043077	10.80	0.0001
ERROR	215	14.14459185	0.06578880		
TOTAL	220	17.69674570			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2.08302112				
Q	0.00076914	0.00030767	0.41112954	6.25	0.0132
A	0.00064086	0.00028985	0.32161727	4.89	0.0281
U	0.19408166	0.04745060	1.10062014	16.73	0.0001
RK	0.04773621	0.02200269	0.30966803	4.71	0.0311
QS	-0.04198843	0.01830389	0.34619773	5.26	0.0228

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
5	0.1853147	0.0003134	Q U QS RK AR
5	0.1858708	0.0003131	Q U QS RK PG
5	0.1863838	0.0003129	Q U A RK SC
5	0.1867562	0.0003128	A U QS RK T
5	0.1868331	0.0003128	Q U A AR SC
5	0.1869794	0.0003127	Q U QS AR SC
5	0.1870493	0.0003127	Q U QS A DEG
5	0.1874022	0.0003125	Q U QS RK SC
5	0.1889411	0.0003120	Q U QS A MS
5	0.1891096	0.0003119	Q U QS A PG
5	0.1898623	0.0003116	Q U QS A PRO
5	0.1904368	0.0003114	Q U QS A SC
5	0.1939895	0.0003100	Q U QS A AGE
5	0.1953933	0.0003095	Q U QS A TM
5	0.1960550	0.0003092	Q U QS A TD
5	0.1963153	0.0003091	Q U QS A AR
5	0.2007236	0.0003074	Q U QS A RK

Table 10

BEST MODEL FOR GOR CIVILIAN SCHOOL GRADUATES

R SQUARE = 0.27556740 C(P) = 3.23121367

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	3.26157594	0.65231519	9.28	0.0001
ERROR	122	8.57427953	0.07028098		
TOTAL	127	11.83585547			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	1.64861891				
U	0.24297149	0.06548738	0.96746043	13.77	0.0003
Q	0.00078738	0.00042958	0.23611150	3.36	0.0693
A	0.00089239	0.00040335	0.34402899	4.90	0.0288
PG	0.19963001	0.07659994	0.47734531	6.79	0.0103
SC	0.25517361	0.10361787	0.42622603	6.06	0.0152

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
5	0.24847150	0.00060256	A U PG Q V
5	0.24867541	0.00060240	A U PG Q T
5	0.25027998	0.00060111	Q U PG SC S
5	0.25335562	0.00059864	Q U PG SC DEG
5	0.25561857	0.00059683	A U SC PG IN
5	0.25565376	0.00059680	A U SC PG TM
5	0.25571895	0.00059675	A U SC PG TD
5	0.25584334	0.00059665	A U SC PG V
5	0.25584841	0.00059664	A U SC PG AGE
5	0.25628965	0.00059629	A U SC PG S
5	0.25689536	0.00059581	A U SC PG AR
5	0.25694585	0.00059576	A U SC PG RK
5	0.25771278	0.00059515	A U SC PG MS
5	0.25997516	0.00059334	A U SC PG T
5	0.26972653	0.00058552	A U SC PG DEG
5	0.27556740	0.00058083	A U SC PG Q

Table 11

BEST MODEL FOR GST CIVILIAN SCHOOL GRADUATES

R SQUARE = 0.25657750 C(P) = -2.39649971

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	1.50376815	0.37594204	7.59	0.0001
ERROR	88	4.35710497	0.04951256		
TOTAL	92	5.86087312			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	1.95252538				
U	0.19175765	0.06112388	0.48730286	9.84	0.0023
T	0.00068311	0.00018764	0.65624186	13.25	0.0005
DEG	0.04368614	0.02548485	0.14549182	2.94	0.0900
AR	0.09869905	0.05158043	0.18128897	3.66	0.0589

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
4	0.23199842	0.00058793	T U AR A
4	0.23259848	0.00058747	T U DEG PG
4	0.23373714	0.00058659	T U AR RK
4	0.23422644	0.00058622	T U AR TM
4	0.23496672	0.00058565	T U AR SC
4	0.23588350	0.00058495	T U AR TD
4	0.23867059	0.00058282	T U DEG TM
4	0.23891107	0.00058263	T U AR MS
4	0.24004831	0.00058176	T U DEG MS
4	0.24078577	0.00058120	T U DEG TD
4	0.24091829	0.00058110	T U AR AGE
4	0.24109338	0.00058096	T U DEG RK
4	0.24340643	0.00057919	T U AR PG
4	0.24777969	0.00057584	T U DEG AGE
4	0.25657750	0.00056911	T U AR DEG

Table 12

BEST MODEL FOR SUCCESS LEVEL 1 (GOR & GST COMBINED)

R SQUARE = 0.18237167 C(P) = -0.06965888

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	0.32176519	0.08044130	8.64	0.0001
ERROR	155	1.44257231	0.00930692		
TOTAL	159	1.76433750			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	3.39086691				
Q	0.00030774	0.00014513	0.04184905	4.50	0..356
U	0.08857614	0.02014927	0.17985423	19.32	0.0001
IN	-0.07312252	0.03097784	0.05185681	5.57	0.0195
QS	-0.01553330	0.00977608	0.02349653	2.52	0.1141

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
4	0.1690200	6.14E-05	U Q DEG TM
4	0.1691035	6.14E-05	U Q IN T
4	0.1691529	6.14E-05	U Q IN V
4	0.1693302	6.14E-05	U Q IN AGE
4	0.1693390	6.14E-05	U Q IN PRO
4	0.1698610	6.14E-05	U Q IN RK
4	0.1699898	6.13E-05	U Q IN TD
4	0.1701068	6.13E-05	U Q IN S
4	0.1702615	6.13E-05	U IN T V
4	0.1705635	6.13E-05	U Q IN MS
4	0.1708002	6.13E-05	U Q IN AR
4	0.1729779	6.11E-05	U Q IN TM
4	0.1733189	6.11E-05	U Q IN SC
4	0.1736999	6.11E-05	U A IN QS
4	0.1738840	6.11E-05	U Q IN PG
4	0.1752452	6.10E-05	U Q IN A
4	0.1757511	6.09E-05	U Q IN DEG
4	0.1823717	6.04E-05	U Q IN QS

Table 13

BEST MODEL FOR SUCCESS LEVEL 2 (GOR & GST COMBINED)

R SQUARE = 0.05932163 C(P) = -6.95655677

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	0.07406629	0.03703315	4.89	0.0087
ERROR	155	1.17448814	0.00757734		
TOTAL	157	1.24855443			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	3.21513171				
A	0.00029180	0.00011811	0.04624814	6.10	0.0146
U	0.03449456	0.01979678	0.02300535	3.04	0.0834

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
2	0.0408962	5.02E-05	A MS
2	0.0410271	5.02E-05	A V
2	0.0416004	5.01E-05	A SC
2	0.0420548	5.01E-05	A TM
2	0.0423825	5.01E-05	A PG
2	0.0429784	5.01E-05	A S
2	0.0435710	5.00E-05	A AGE
2	0.0436425	5.00E-05	A QS
2	0.0436508	5.00E-05	A IN
2	0.0438965	5.00E-05	A T
2	0.0452963	4.99E-05	Q U
2	0.0455928	4.99E-05	A RK
2	0.0459496	4.99E-05	A AR
2	0.0471937	4.98E-05	A PRO
2	0.0472397	4.98E-05	A TD
2	0.0513026	4.96E-05	A Q
2	0.0522774	4.96E-05	A DEG
2	0.0593216	4.92E-05	A U

Table 14

BEST MODEL FOR SUCCESS LEVEL 3 (GOR & GST COMBINED)

R SQUARE = 0.20531082 C(P) = -2.67596622

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	0.25254368	0.08418123	5.25	0.0029
ERROR	61	0.97751170	0.01602478		
TOTAL	64	1.23005538			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	3.66360954				
TM	0.03490891	0.01220367	0.13112452	8.18	0.0058
AGE	-0.02679824	0.01133151	0.08962493	5.59	0.0212
IN	0.08068615	0.03259226	0.09821122	6.13	0.0161

S(P) Criteria

NUMBER	R-SQUARE	S(P)	VARIABLES IN MODEL
3	0.1375752	0.0002898	TM AGE DEG
3	0.1377273	0.0002898	TM AGE MS
3	0.1382703	0.0002896	IN TM PRO
3	0.1394495	0.0002892	QS TM A
3	0.1396277	0.0002892	TM AGE U
3	0.1412676	0.0002886	IN TM V
3	0.1417281	0.0002884	IN PRO Q
3	0.1481783	0.0002863	QS TM Q
3	0.1502148	0.0002856	TM AGE AR
3	0.1510297	0.0002853	IN AR Q
3	0.1576776	0.0002831	TM AGE Q
3	0.1577268	0.0002831	IN TM A
3	0.1652644	0.0002805	PRO TM AGE
3	0.1666392	0.0002801	IN TM Q
3	0.1691897	0.0002792	QS TM TD
3	0.1753622	0.0002771	IN TM TD
3	0.1937810	0.0002710	QS TM AGE
3	0.2053108	0.0002671	IN TM AGE

Research Objectives

The following comments address the research questions posed in chapter one.

1. The strength of the relationship between UGPA and GGPA depends on which model is considered. It is the single greatest predictor with the highest "F" value (8 of 11 times) of any other variable contributing to Operations Research students' final GGPA. UGPA is found in every model but one.

2. GRE scores (Quantitative, Total, or Analytical) are second in importance only to UGPA and are also found in every model but one. Table 15 shows each model and its respective predictor variables.

Table 15

Predictor Variables in Models

	ALL			ACADEMY GRADS			CIVILIAN GRADS			SUCCESS LEVEL		
	BOTH	GOR'S	GST'S	BOTH	GOR'S	GST'S	BOTH	GOR'S	GST'S	S1	S2	S3
UGPA	X	X	X	X	X	X	X	X	X	X	X	
GRE-T		X	X						X			
GRE-Q	X	X	X	X		X	X	X		X		
GRE-A	X	X			X		X	X			X	
GRE-V					X							
PG	X	X	X		X			X				
DEG	X	X		X	X				X			
MS	X		X	X		X						
IN	X									X		X
QS	X	X					X			X		
SC		X				X		X				
TD			X									
RK							X					
AR						X			X			
TM												X
AGE												X

3. Since GRE-Q enters more models with higher 'F' values than other variable (except UGPA), it is a better predictor of academic success other GRE scores.

4. The degree of GGPA predictability is dependent on which model is considered. The higher the R^2 value the better the regression line fits the data. GST Academy graduates and the entire group of GOR's have the two highest R^2 values among the models. Table 16 presents a summary of the R^2 values and the total number of variables in each model.

Table 16

Model Summary

MODEL	R^2	# of VARIABLES
ALL	0.22967586	8
GOR	0.30624043	8
GST	0.25390263	6
ALL ACADEMY	0.28870451	4
GOR ACADEMY	0.30580409	5
GST ACADEMY	0.42664654	5
ALL CIVILIAN	0.20072356	5
GOR CIVILIAN	0.27556740	5
GST CIVILIAN	0.25657750	4
SUCCESS (S1)	0.18237167	4
SUCCESS (S2)	0.05932163	2
SUCCESS (S3)	0.20531082	3

5. The indicator variable (DEG) which defined the type of undergraduate (Appendix A) degree entered four of the models (see table 15). In every model DEG was assigned a negative 'β' value. This meant that an operations research (1) or mathematics degree (2) did not degrade the prediction function as much as one of the other degrees. The DEG was significant in the overall model.

6. The time between undergraduate and graduate admission (TD) only entered one model (table 15) and therefore was not significant in GGPA prediction.

7. The indicator variable distinguishing aeronautically rated versus non-rated officers (AR) entered only two of the GST models. It showed that a rated academy GST graduate received a lower final prediction whereas a rated civilian undergraduate GST graduate received a higher GGPA prediction. Overall, aeronautical rating did not prove to be significant enough to effect the majority of the models.

8. Although the students' branch of service (SC) entered three models, SC was not considered significant. There was a relatively small number of non-air force students (7.8%) compared to the entire population.

9. The indicator variable displaying academy graduates versus civilian graduates entered three models including the combined GOR and GST model. In the overall model (GOR and GST combined) an academy undergraduate diploma yielded a a lower predicted GGPA.

10. The 'Quality of Schools' factor (QS) entered 4 of 9 possible models (this factor was not considered in the academy graduates). It appropriately reduced the final GGPA prediction in each model based on the rated university's competitive ranking (Appendix B and E).

Validity

An analysis of predictability for the GOR and GST model was performed. Appendix J shows the actual GGPA versus the predicted value, 95% confidence interval (alpha = .05), the standard error of prediction, and the associated residuals. The average absolute error of prediction per observation was 0.2311769 and was obtained as follows:

$$\left[\frac{SSR}{OBS}\right]^{\frac{1}{2}} \qquad (6)$$

where
SSR = Sum square of the residuals
OBS = Number of observations

Another test of model prediction accuracy was accomplished by creating an array which compares each actual GGPA by 'success level' (page 28) against its predicted value. For example, an actual GGPA of 3.89 falling in success level 1 (S1) and predicted to be 3.54 (S2), would be placed in the top center position of the matrix (table 17). This analysis was performed to determine how well the model predicted GGPA within a given grade range.

This analysis showed that of the 86 students who were predicted to achieve a GGPA higher than 3.67 (S1), 80 of them finished at least S2 or better. Furthermore, 78% (223 of 283) of the students who were predicted to fall within the S2 range, finished with a GGPA of S2 and higher. Unfortunately, of the 71 students finishing in S3, only 6 of

them (8%) were actually predicted to finished in the lowest success level. This indicates that the model tends to be more accurate at the middle grade point averages. Table 17 shows the predicted versus actual GGPA values as a function of success levels.

Table 17

Predicted vs. Actual GGPA

		PREDICTED VALUES			
A V		S1(3.67-4.00)	S2(3.34-3.66)	S3(3.33 & below)	
C A	S1	62	95	0	Σ 157
T L					
U U	S2	19	128	9	Σ 156
A E					
L S	S3	5	60	6	Σ 71
		Σ 86	Σ 283	Σ 15	

Future Proposed Research

There are many factors influencing a student's level of success in graduate school.

1. Undergraduate mathematics courses should be examined for their possible relationship and correlation to GGPA.

2. UGPA in a student's final year of undergraduate school should be examined for its relationship and correlation to GGPA.

3. This study did not consider motivation factors except those measured by achievement scores. One possible way to quantify this determinant is to ascertain whether an officer is a 'volunteer' or 'non-volunteer' for attendance at AFIT.

4. Efforts to reduce 'grade inflation' and quantify a 'Quality of Schools' factor should continued.

5. The models developed in this study need further evaluation to determine which one actually is most appropriate for the given situation. For example, should an academy graduate vying for GST selection be checked by the GST model (R^2 = 0.25390263), the overall model (R^2 = 0.22967586), or perhaps the model for GST academy graduates (R^2 = 0.42664654).

6. A study leading to the development of a written examination to evaluate those skills required to succeed in AFIT's Operations Research disciplines should be conducted.

7. Additional analysis should be conducted to determine how these models can be used to predict which program an individual has greater success potential.

8. These models need to be further validated for their ability to successfully predict GGPA. Squared variables and interaction terms not explored may improve some models.

9. A methodology to quantify and integrate military performance as it relates to graduate success may enhance model predictability.

Summary

AFIT enjoys a greater selection accuracy than most private graduate institutions and therefore has a greater success rate. The population of potential students are United States Air Force and Army officers who have already

been subjected to various screening and evaluations criteria.

This research project has generated prediction models for the two Operations Research Programs within AFIT's Operational Sciences Department. Eighteen predictor variables were examined to determine their relationship with final GGPA. The regression models have shown that UGPA is the single most significant predictor of GGPA. In support of the literature findings, each variable's exact significance and contribution depends on the group considered.

The 'Quality of Schools' factor did not seem to reduce variance in GGPA and compensate for undergraduate grade inflation. Further research is recommended in this area.

There are many factors which contribute to a student's performance in graduate school. The R^2 and correlation factors determined in this study certainly imply that there are positive relationships between the predictor variables and AFIT graduate school performance as measured by GGPA. Although these relationships may be statistically significant, the derived prediction equations may not be reliable enough to affirm a true and credible prediction. As previously mentioned, further research is proposed to further validate these predictor regression models.

The Department of Defense's budget is becoming more constrained. If this study can aid in identifying those

factors which contribute to success in the Operations Research disciplines, then AFIT dollars will be spent on the best possible students. Further research of predictors of graduate performance may prove to be valuable in aiding AFIT admissions procedures and selection process.

APPENDIX A: Key to Database

VARIABLE DESCRIPTION	VALUE	DATA COLUMN
Student number	0-9999	1-4
GRE-V	Graduate Records Exam (Verbal)	6-8
GRE-Q	Graduate Records Exam (Quantitative)	10-12
GRE-T	Graduate Records Exam (Total)	14-17
GRE-A	Graduate Records Exam (Analytical)	19-21
UGPA	Final undergraduate grade point average	23-26
GGPA	Final graduate grade point average	28-31
Rank	Rank at time of admission 1 = 2LT 2 = 1LT 3 = Capt 4 = Major 5 = LtCol 6 = Civilian	33
Time in Military	Time at AFIT admission (in years)	35-36
Time since undergraduate degree	Time at AFIT admission (in years)	38-39
Age	Age at AFIT admission (in years)	41-42
Sex	Student's Sex 0 = Male 1 = Female	44
Graduate degree	Other graduate degree (at time of admission) 0 = No degree 1 = degree	46

Degree	Type of undergraduate degree 1 = operation research 2 = mathematics 3 = sciences (biology, physics,chemistry, etc.) 4 = engineering (mechanical, civil, electrical, etc.) 5 = business (administration, financial, marketing, etc.) 6 = other	48
Marital Status	Marital Status (at time of entry) 0 = Married 1 = Unmarried	50
Student Code	Student's branch of service 0 = Air Force 1 = Other (Army, Foreign, Civilian)	52
Flight Status	Aeronautical Rating 1 = Pilot or Navigator 0 = Non-pilot (non-rated)	54
AFIT Program	0 = GOR 1 = GST	56
Academy Graduate	0 = Non-academy graduate 1 = U.S. Service Academy graduate	58
Quality of Schools	Undergraduate school (at which degree was earned)	60

APPENDIX B: Quality of Schools Indicator Variables

BARRON'S COLLEGE RANKINGS[1]

CATEGORY	HS CLASS RANK	HS GPA	MEDIAN (SAT SCORE)	MEDIAN (ACT SCORE)	INDICATOR VARIABLE
MOST COMPETITIVE	10-20%	A to B+	625-800	28	1
HIGHLY COMPETITIVE	20-30%	B+ to B	575-625	26-28	2
VERY COMPETITIVE	30-50%	no less than B-	525-575	23-26	3
COMPETITIVE	upper 2/3	some req B+ others C+ or C	425-525	20-23	4
LESS COMPETITIVE	top 75%	C	below 425	below 20	5
NON-COMPETITIVE	evidence of hs grad[2]	some require for records	some require for records		6

[1]This table is complied from information provided in Barron's Profiles of American Colleges (1)

[2]Most of these schools will admit applicants limited only by capacity.

APPENDIX C: Sample Data Set

7856	570	740	1310	450	2.88	3.67	4	11	11	34	1	1	2	0	1	1	1	0	4
7857	660	700	1360	710	3.56	3.45	2	03	03	25	0	0	4	1	0	1	0	1	1
7859	580	650	1230	690	3.71	4.00	1	01	01	24	0	1	1	1	1	0	1	0	2
7860	500	500	1000	560	3.21	3.56	4	11	13	36	1	0	4	1	0	1	1	0	6
7861	450	560	1010	690	2.99	3.67	2	09	02	31	0	0	2	0	1	0	1	0	5
7862	480	540	1020	530	3.34	3.56	2	04	04	27	0	1	5	1	0	1	1	1	1
7869	660	740	1400	720	3.01	3.63	4	13	13	35	1	0	3	0	1	0	1	0	1

APPENDIX D: GOR and GST CLASS STATISTICS

GST

Class	Start	Graduates	Army	Foreign[a]	Withdrawn	In Study	NG
GST79M	15	14	0	0	0	15	1
GST80M	16	16	0	0	0	16	0
GST81M	21	20[b]	0	0	0	20	0
GST82M	23	23	0	0	0	22[c]	0
GST83M	21[d]	21[e]	1	0	1	21	0
GST84M	23	23	4	0	0	22[c]	0
GST85M	23	23	5	0	0	23	0
GST86M	25	24	1	0	1	23[c]	0
GST87M	21	20	2	0	0	20[c]	1
					TOTAL	182	

GOR

Class	Start	Graduates	Army	Foreign[a]	Withdrawn	In Study	NG
GOR77D	14	7[b]	1	0	3	11	3
GOR78D	19	19	1	0	0	19	0
GOR79D	19	16[b]	1	0	0	18	2
GOR80D	15	14[b]	1	0	0	13[c]	0
GOR81D	23	23	3	3	0	20	0
GOR82D	23	21[b]	3	3	0	19	1
GOR83D	24	22	0	3	2	19	0
GOR84D	20[d]	18[f]	0	0	0	18	1
GOR85D	22	22	0	1	0	21	0
GOR86D	23	23	1	3	0	20	0
GOR87D	25	24	4	1[g]	0	24	0
					TOTAL	202	

NOTES:
a. Foreign students not included in this study
b. 1 Student transferred out of the program
c. 1 Student record was not available
d. 1 Civilian student
e. 1 Student transferred into the program
f. 2 Students transferred out of the program
g. Extended 1 quarter

APPENDIX E: GOR and GST Students' Undergraduate Institutions

UNDERGRADUATE INSTITUTION	BARRON'S RATING[1]	# OF STUDENTS GST	GOR	TOTAL
Air Force Academy, CO.	1	73	62	135
Angelo State University, TX.	5	0	1	1
Arizona State University, AZ.	4	0	2	2
Auburn University, AL.	4	1	0	1
Austin Peay State University, TN.	5	1	0	1
Baptist College, SC.	5	0	1	1
Boston University, MA.	3	1	0	1
Bowdoin College, ME.	1	1	0	1
Bowling Green State University, OH.	4	1	1	2
Cal State Univ., Dominguez Hills, CA.	5	1	0	1
California State University, CA.	4	0	1	1
California State University, Fresno, CA.	4	1	0	1
Capital University, OH.	4	0	1	1
Carnegie Melon University, PA.	1	1	1	2
Claremont Colleges, Harvey Mudd Col, CA.	1	0	1	1
Clemson University, SC.	4	0	2	2
Colorado State University, CO.	4	3	0	3
Cornell University, NY.	1	2	0	2
Creighton University, NE.	4	0	1	1
Cumberland College, PA.	5	1	0	1
Drexel University, PA.	3	0	1	1
East Texas State University, TX.	5	0	2	2
Eastern Illinois University, IL.	4	1	0	1
Fayetteville State University, NC.	5	0	1	1
Georgia Institute of Technology, GA.	4	1	2	3
Howard University, Washington, D.C.	4	1	0	1
Idaho State University, ID.	6	1	0	1
Illinois Institute of Technology, IL.	3	1	0	1
Illinois Wesleyan University, IL.	3	1	0	1
Indiana State University, IN.	6	0	1	1
Indiana University, IN.	4	1	1	2
Indiana University of Pennsylvania, PA.	4	0	1	1
Iona College, NY.	4	1	0	1
Kansas State University, KS.	6	1	0	1
Kearney State College, NE.	4	0	1	1
Kent State University, OH.	5	1	1	2
Lehigh University, PA.	2	0	3	3
Louisiana State University & A & M, LA.	4	1	0	1
Louisiana Technical State Univ., LA.	6	0	1	1
Manhattan College, NY.	4	2	0	1
Mankota State University, MN.	5	1	0	1
Marygrove College, MI.	4	0	1	1
Massachusetts Inst. of Technology, MA.	1	0	1	1
Memphis State University, TN.	5	1	1	2
Miami University, OH.	4	1	2	3
Michigan State University, MI.	4	0	1	1

Michigan Technological University, MI.	4	0	1	1
Michigan Technological University, MI.	4	1	0	1
New Mexico Inst. of Mining & Tech, NM.	3	1	0	1
New Mexico State, NM.	5	1	0	1
Newberry College, SC.	4	0	1	1
Nicholls State University, LA.	5	1	0	1
North Dakota State University, ND.	4	1	0	1
Northern Michigan University, Mi.	5	0	1	1
Norwich University, VT.	4	0	1	1
Ohio State University, OH.	6	2	1	3
Oklahoma Christian State College, OK.	6	0	1	1
Oklahoma State University, OK.	4	1	4	5
Old Diminion University, VA.	4	0	1	1
Oregon State University, OR.	4	2	0	2
Parks College of St. Louis, IL.	4	0	1	1
Pennsylvania State University, PA.	4	2	1	3
Polytechnic Institute of New York, NY.	2	1	0	1
Portland State University, OR.	4	0	1	1
Providence College, RI.	4	1	0	1
Purdue University, IN.	4	1	1	2
Rutgers University, NJ.	3	0	1	1
San Diego State, CA.	4	0	1	1
Seton Hall University, NJ.	4	1	0	1
Siena College, NY.	4	0	1	1
Simmons College, MA.	4	1	0	1
Southeast Missouri State University, MO.	5	1	1	2
Southern Illinois U., Edwardsville, IL.	5	1	2	3
Southern Methodist University, TX.	4	0	1	1
Southern University & A & M College, LA.	5	1	0	1
Southern Utah State College, UT.	6	0	1	1
Southwest Texas State University, TX.	4	1	1	2
St. Bonaventure, NY.	4	1	0	1
St. Joseph's College, IN.	4	1	0	1
St. Louis University, MO.	4	0	1	1
St. Mary's College, MN.	4	0	1	1
St. Mary's Univ. of San Antonio, TX.	4	0	2	2
St. Michael's College, VT.	4	0	1	1
St. Olaf College, MN.	2	0	1	1
Stevens Institute of Technology, NJ.	2	2	1	3
SW Missouri State, MO.	5	1	0	1
Syracuse University, NY.	4	0	1	1
Texas A & M, TX.	4	4	1	5
Texas Christian University, TX.	4	1	0	1
Texas Tech University, TX.	4	0	2	2
The Citadel, SC.	4	1	3	4
The King's College, NY.	4	0	1	1
Thomas More College, KY.	4	0	1	1
Tulane University, LA.	3	1	0	1
University of Akron, OH.	4	0	1	1
University of Arizona, AZ.	4	0	2	2
Univ. of Arkansas, Fayetteville, AK.	5	0	1	1
University of Central Florida, FL.	4	0	1	1

University of Colorado, Col Springs, CO.	4	1	0	1
University of Connecticut, CT.	3	1	0	1
University of Detroit, MI.	4	1	0	1
University of Evansville, IN.	4	0	1	1
University of Florida, FL.	4	0	1	1
University of Georgia, GA.	4	0	1	1
University of Hawaii, HI.	4	1	1	2
University of Ill., Chicago Circle, IL.	4	1	0	1
University of Illinois, Urbana, IL.	3	2	1	3
University of Iowa, IA.	4	0	1	1
University of Kentucky, KY.	4	1	1	2
University of Louisville, KY.	4	2	2	4
University of Lowell, MA.	5	1	1	2
Univ. of Massachusetts, Amherst, MA.	4	1	0	1
University of Michigan, Ann Arbor, MI.	3	1	1	2
University of Minnesota, Duluth, MN.	6	1	0	1
Univ. of Minnesota, Twin Cities, MN.	4	2	2	4
University of Mississippi, MS.	4	0	3	3
University of Missouri, MO.	4	1	0	1
University of Nebraska, NE.	6	2	1	3
University of Nevada, NV.	4	1	0	1
University of New Hampshire, NH.	4	1	0	1
University of North Carolina, NC.	4	0	1	1
University of Northern Colorado, CO.	4	0	1	1
University of Northern Iowa, IA.	4	0	1	1
University of Notre Dame, IN.	2	0	1	1
University of Oklahoma, OK.	4	0	1	1
University of Puerto Rico, PR.	4	0	1	1
University of South Carolina, SC.	4	0	1	1
University of Southern Mississippi, MI.	5	0	2	2
University of Tennessee, TN.	4	0	1	1
University of Texas, Arlington, TX.	4	1	0	1
University of Texas, El Paso, TX	5	1	0	1
University of Tulsa, OK.	4	1	1	2
University of Utah, UT.	4	0	2	2
University of Vermont, VT.	3	0	1	1
University of Washington, WA.	3	0	2	2
University of Wisconsin, Milwaukee, WI.	4	2	2	4
University of Wyoming, WY.	6	1	0	1
US Military Academy, NY.	1	12	10	22
US Naval Academy, MD.	1	0	1	1
VA Polytechnic Institute & State U, VA.	3	2	1	3
Virginia Military Institute, VA.	4	2	2	4
Washburn University of Topeka, KS.	6	0	3	3
Washington College, MD.	4	1	0	1
West Virginia University, WV.	4	1	1	2
Western Connecticut State College, CT.	4	0	1	1
Westmar College, IA.	4	0	1	1
Wichita State University, KS.	6	0	1	1
Wittenburg University, OH.	4	0	1	1
Worcester Polythenic Institute, MA.	2	0	1	1
Wright State University, OH.	5	0	1	1

APPENDIX F: Pearson Correlation Matrix (Predictor Variables versus GGPA)

	ALL	GOR	GST	ALL S1	ALL S2	ALL S3
GRE-V	0.10860	0.02518	0.21964	0.07480	0.05539	0.04936
GRE-Q	0.32165	0.32397	0.31665	0.20026	0.15537	0.19546
GRE-T	0.25697	0.20540	0.33134	0.16161	0.12801	0.07674
GRE-A	0.25793	0.35448	0.12000	0.17115	0.20223	-0.09975
UGPA	0.30220	0.26241	0.35730	0.35122	0.14927	-0.14740
RK	0.19562	0.00086	0.04234	-0.10922	-0.06973	0.14847
TM	-0.01080	0.03137	0.06249	-0.04535	-0.03336	0.20820
TD	-0.03347	-0.05450	0.05451	-0.11513	-0.08787	0.05718
AGE	-0.03621	-0.07056	0.05854	-0.09573	-0.06584	0.08590
S	0.02641	0.02279	---	0.05047	0.04938	-0.12414
PG	0.10499	0.07559	0.10313	-0.04526	0.01526	0.01944
DEG	-0.08265	-0.10305	-0.02869	-0.16664	-0.08921	0.14403
MS	-0.04590	0.00171	-0.15752	0.00400	-0.00654	0.01273
SC	0.01182	0.09950	-0.06741	-0.05808	0.00139	0.08536
AR	0.00469	-0.02201	0.09325	-0.06071	-0.06210	0.19146
PRO	-0.05114	---	---	-0.09262	-0.07755	0.24936
IN	0.05976	0.11762	0.00371	-0.13959	-0.03152	0.30154
QS	-0.13679	-0.21177	-0.05670	0.04684	0.02850	-0.28000

	ACADEMY ALL	ACADEMY GOR	ACADEMY GST	CIVILIAN ALL	CIVILIAN GOR	CIVILIAN GST
GRE-V	0.06976	-0.01112	0.16713	0.13386	0.03347	0.29267
GRE-Q	0.35970	0.33357	0.36038	0.30142	0.31663	0.27464
GRE-T	0.25209	0.20484	0.30451	0.26130	0.19889	0.36570
GRE-A	0.21021	0.37509	0.08686	0.27868	0.34790	0.14683
UGPA	0.40772	0.30113	0.49160	0.25858	0.29337	0.25110
RK	-0.09743	-0.07959	-0.00378	0.00802	-0.01758	0.06801
TM	-0.01743	0.03295	0.08241	-0.01150	-0.06753	0.03599
TD	-0.01509	0.03295	0.08679	-0.04419	-0.09891	0.03384
AGE	-0.02056	0.06152	0.03351	-0.04227	-0.11492	0.08011
S	-0.03202	-0.06902	---	0.05170	0.06467	---
PG	0.08243	0.13867	0.11267	-0.06953	0.15493	0.11485
DEG	-0.26636	-0.26392	-0.21340	-0.02195	-0.07635	0.17226
MS	-0.08479	-0.02404	-0.26938	-0.02500	-0.00043	-0.07592
SC	-0.08816	-0.02473	-0.14517	0.05343	0.16630	-0.01918
AR	-0.02040	0.07597	-0.01277	-0.00356	-0.12247	0.18426
PRO	-0.16283	---	---	0.00391	---	---
QS	---	---	---	-0.23068	-0.26243	-0.17753

APPENDIX G: SUMMARY OF REGRESSION EQUATIONS

GOR and GST PROGRAMS (COMBINED), n = 384

2.28814680 + GRE-Q(0.0008214680) + GRE-A(0.00053634)
+ UGPA(0.18795536) + PG(0.08079898) + DEG(-0.04828857)
+ MS(-0.04828857) + IN(-0.08374610) + QS(-0.04406252)

GOR PROGRAM, n = 202

2.26360662 + UGPA(0.19788214) + GRE-Q(0.00109840)
+ GRE-T(-0.00047072) + GRE-A(0.00112562) + PG(0.16597944)
+ DEG(-0.03974217) + SC(0.14200377) + QS(-0.03685455)

GST PROGRAM, n = 182

2.03249403 + UGPA(0.21424465) + GRE-Q(0.00074854)
+ GRE-T(0.00024338) + TD(0.00776757) + PG(0.4135680)
+ MS(-0.10752851)

APPENDIX H: PREDICTOR VARIABLE AVERAGES

For GOR and GST Combined

VAR	n	MEAN	STD DEV	MINIMUM	MAXIMUM
GGPA	384	3.577	0.264	2.620	4.00
UGPA	377	3.096	0.376	2.160	4.00
GRE-V	330	546.000	85.756	300.000	790.00
GRE-Q	330	693.000	69.162	450.000	870.00
GRE-T	330	1240.060	127.484	760.000	1670.00
GRE-A	184	617.011	87.767	350.000	800.00
AGE	383	28.878	3.657	21.000	39.00
TM	365	6.644	3.487	0.000	18.00
TD	382	6.768	3.416	0.000	16.00

GOR

VAR	n	MEAN	STD DEV	MINIMUM	MAXIMUM
GGPA	202	3.589	0.279	2.720	4.00
UGPA	197	3.175	0.371	2.200	4.00
GRE-V	174	534.770	78.156	300.000	770.00
GRE-Q	174	695.402	69.587	470.000	870.00
GRE-T	174	1230.057	118.923	920.000	1530.00
GRE-A	117	618.889	84.708	350.000	800.00
AGE	201	27.259	3.428	21.000	39.00
TM	196	5.077	3.272	0.000	18.00
TD	201	5.129	3.068	0.000	15.00

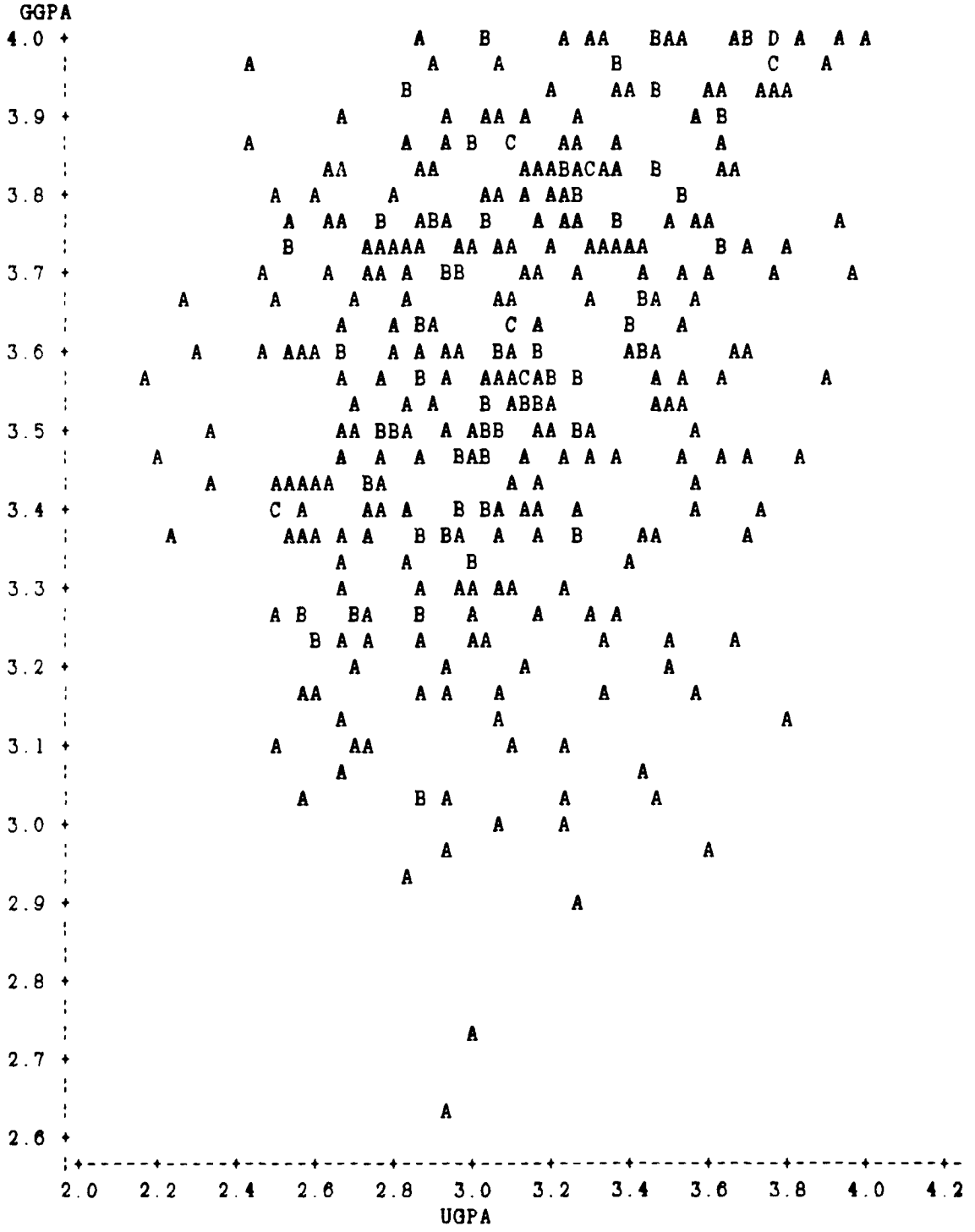
GST

VAR	n	MEAN	STD DEV	MINIMUM	MAXIMUM
GGPA	182	3.564	0.245	2.620	4.00
UGPA	180	3.009	0.365	2.160	3.91
GRE-V	156	558.526	92.156	310.000	790.00
GRE-Q	156	690.320	68.809	450.000	830.00
GRE-T	156	1251.218	135.919	760.000	1670.00
GRE-A	67	613.731	93.433	430.000	790.00
AGE	182	30.665	3.019	22.000	39.00
TM	169	8.461	2.779	0.000	15.00
TD	181	8.586	2.814	0.000	16.00

APPENDIX I: Scatterplots

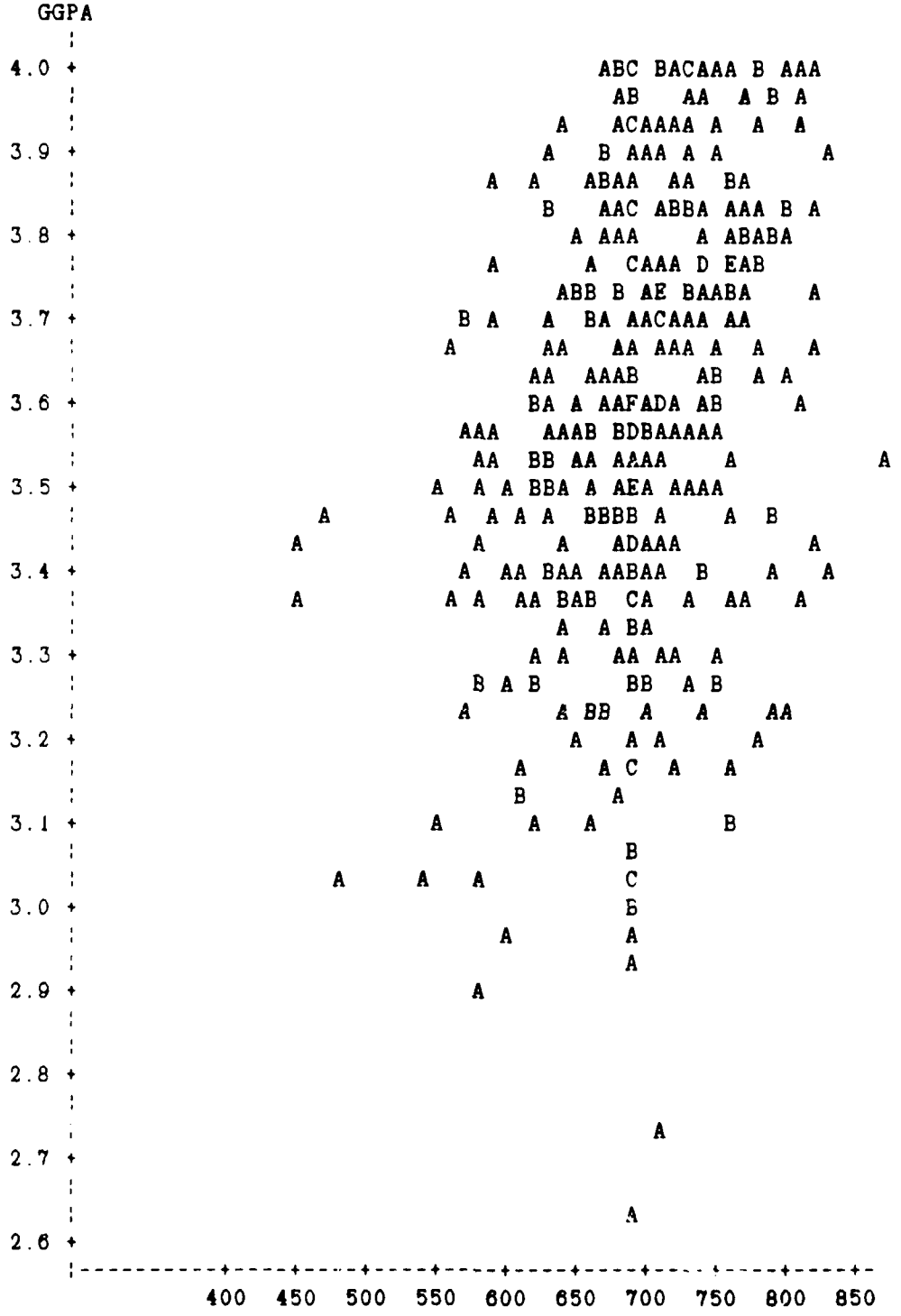
PRELIMINARY SCATTERPLOT OF COMBINED CLASSES (GGPA vs. UGPA)

(LEGEND: A = 1 OBSERVATION, B = 2 OBS, etc.)



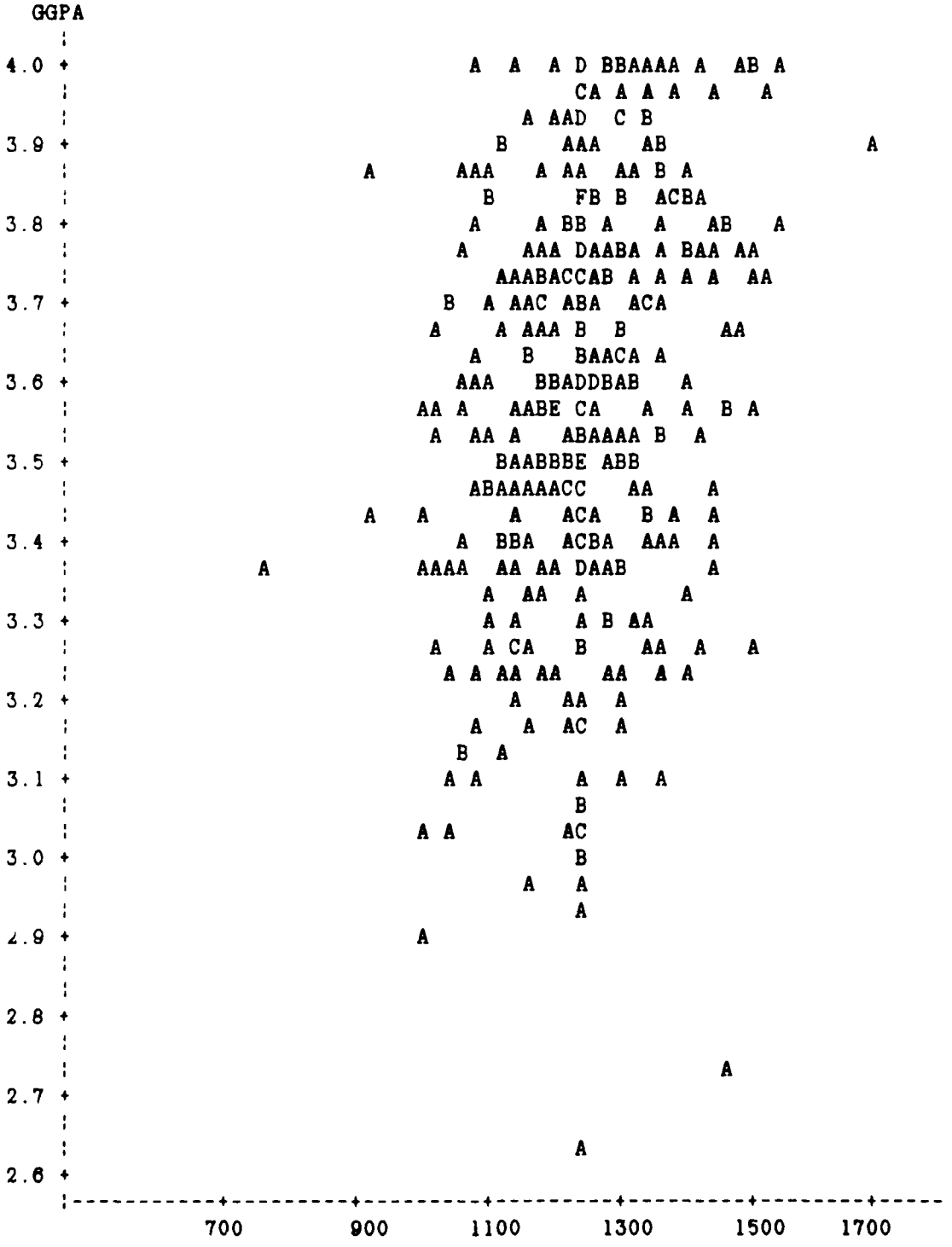
PRELIMINARY SCATTERPLOT OF COMBINED CLASSES (GGPA vs. GRE-Q)

(LEGEND: A = 1 OBSERVATION, B = 2 OBS, etc.)



PRELIMINARY SCATTERPLOT OF COMBINED CLASSES (GGPA vs. GRE-T)

(LEGEND: A = 1 OBSERVATION, B = 2 OBS, etc.)



APPENDIX J: Actual versus Predicted GGPA

BOTH GOR'S AND GST'S COMBINED

OBS	ACTUAL	PREDICTED VALUE	STD ERR PREDICT	LOWER95% PREDICT	UPPER95% PREDICT	RESIDUAL
1	3.4000	3.4945	.0387681	3.0282	3.9607	-.094455
2	3.8200	3.5885	.0358645	3.1232	4.0539	.231500
3	3.6700	3.4839	.0422536	3.0164	3.9513	.186100
4	3.7000	3.5911	.0258217	3.1283	4.0539	.108900
5	3.7300	3.6055	.0260653	3.1426	4.0683	.124500
6	3.7500	3.6807	.0388164	3.2144	4.1469	.069341
7	3.5000	3.6068	.0295539	3.1432	4.0705	-.106804
8	3.2400	3.5894	.0344624	3.1245	4.0544	-.349433
9	3.2100	3.5834	.0328065	3.1189	4.0479	-.373431
10	3.1900	3.6916	.0252136	3.2290	4.1543	-.501628
11	3.6900	3.4973	.0362846	3.0318	3.9628	.192700
12	3.3900	3.3690	.0404017	2.9022	3.8358	.020974
13	3.4400	3.5270	.0312915	3.0629	3.9911	-.087014
14	3.7300	3.6660	.0315946	3.2018	4.1302	.064004
15	3.4600	3.5732	.0435210	3.1053	4.0411	-.113219
16	3.3400	3.5623	.0322871	3.0980	4.0267	-.222311
17	3.2500	3.3239	.0553194	2.8512	3.7966	-.073879
18	3.8800	3.6492	.0320596	3.1849	4.1135	.230800
19	3.1300	3.4956	.0243065	3.0331	3.9581	-.365616
20	3.5500	3.7058	.0408668	3.2389	4.1728	-.155823
21	3.2300	3.4962	.0369590	3.0305	3.9619	-.266197
22	3.2700	3.6024	.0330131	3.1379	4.0670	-.332421
23	3.4300	3.5461	.0336279	3.0813	4.0108	-.116066
24	3.7800	3.7160	.0341993	3.2511	4.1809	.064004
25	3.8200	3.7447	.0314691	3.2805	4.2088	.075317
26	3.9900	3.8405	.0591033	3.3661	4.3150	.149500
27	3.5200	3.5540	.0454269	3.0854	4.0225	-.033956
28	3.1600	3.5023	.0360393	3.0368	3.9677	-.342259
29	3.6200	3.4965	.0477921	3.0270	3.9660	.123500
30	3.8700	3.5668	.0376072	3.1009	4.0327	.303200
31	3.4200	3.3516	.0578124	2.8777	3.8254	.068433
32	3.4600	3.4044	.0473747	2.9351	3.8737	.055607
33	3.4900	3.6557	.0322517	3.1913	4.1200	-.165685
34	3.2700	3.6492	.0277245	3.1860	4.1124	-.379224
35	3.8700	3.6500	.0314683	3.1859	4.1142	.220000
36	3.5900	3.6063	.0242054	3.1439	4.0688	-.016319
37	3.5700	3.7043	.0391316	3.2379	4.1707	-.134274
38	3.4800	3.6599	.0426033	3.1923	4.1274	-.179875
39	3.3800	3.7771	.0351640	3.3120	4.2423	-.397126
40	3.4900	3.4382	.0412336	2.9711	3.9053	.051783
41	3.7600	3.6421	.0433314	3.1743	4.1099	.117900
42	3.3900	3.5211	.0465406	3.0521	3.9901	-.131122
43	3.5500	3.5685	.0230808	3.1062	4.0307	-.018472
44	3.2700	3.3689	.0402395	2.9022	3.8357	-.098906

45	3.3400	3.7063	.0362271	3.2408	4.1718	-.366327
46	3.3500	3.5713	.0354555	3.1060	4.0365	-.221253
47	3.3700	3.4447	.0287697	2.9813	3.9082	-.074730
48	3.8000	3.7145	.0426042	3.2469	4.1820	.085542
49	3.7800	3.5980	.0368785	3.1323	4.0636	.182000
50	3.9200	3.6345	.0433775	3.1667	4.1023	.285500
51	3.7200	3.7768	.0362243	3.3114	4.2423	-.056839
52	3.3900	3.6721	.0331705	3.2075	4.1367	-.282120
53	3.5700	3.7531	.0315147	3.2889	4.2172	-.183096
54	3.2500	3.4016	.0431260	2.9339	3.8694	-.151612
55	3.8300	3.6763	.0261343	3.2135	4.1392	.153700
56	3.3100	3.6280	.0318749	3.1637	4.0922	-.317959
57	3.3900	3.3864	.0374782	2.9205	3.8522	.003612
58	4.0000	3.8445	.0396984	3.3779	4.3111	.155500
59	3.4800	3.5178	.0399614	3.0511	3.9844	-.037778
60	3.5400	3.5546	.0251485	3.0919	4.0172	-.014561
61	3.9500	3.8611	.0429952	3.3934	4.3288	.088858
62	3.8200	3.7100	.0255777	3.2472	4.1727	.110000
63	3.4000	3.4688	.0331637	3.0042	3.9334	-.068814
64	3.4900	3.4902	.0285608	3.0268	3.9536	-1.7E-04
65	3.6000	3.5983	.0385612	3.1321	4.0645	.001713
66	3.3800	3.1899	.0447120	2.7216	3.6582	.190100
67	3.9400	3.6571	.0381869	3.1910	4.1232	.282900
68	3.6300	3.5389	.0230191	3.0767	4.0011	.091133
69	3.9800	3.7452	.0379760	3.2791	4.2112	.234800
70	3.6100	3.5968	.0212394	3.1349	4.0587	.013196
71	3.6700	3.6291	.0416383	3.1619	4.0963	.040877
72	3.5700	3.5470	.0337598	3.0822	4.0117	.023020
73	3.6800	3.6612	.0225643	3.1990	4.1233	.018845
74	3.8300	3.8033	.0362306	3.3378	4.2688	.026678
75	3.9500	3.4703	.0342684	3.0053	3.9352	.479700
76	3.5400	3.6715	.0383095	3.2054	4.1376	-.131519
77	3.8900	3.6238	.0572301	3.1503	4.0974	.266200
78	3.3700	3.2707	.0374614	2.8048	3.7365	.099345
79	3.4800	3.5461	.0319536	3.0819	4.0104	-.066131
80	3.9000	3.5086	.0327647	3.0441	3.9731	.391400
81	3.2300	3.6193	.0327084	3.1548	4.0837	-.389259
82	3.9900	3.6072	.0345770	3.1423	4.0722	.382800
83	3.3000	3.5369	.0311176	3.0728	4.0009	-.236888
84	3.7700	3.6040	.0337201	3.1393	4.0688	.166000
85	3.6200	3.6709	.0427195	3.2033	4.1386	-.050950
86	3.6600	3.4861	.0245896	3.0236	3.9487	.173900
87	3.6600	3.5482	.0250739	3.0855	4.0108	.111800
88	3.7300	3.5645	.0234542	3.1022	4.0268	.165500
89	3.2500	3.6367	.0364056	3.1711	4.1022	-.386658
90	3.2600	3.3290	.0463293	2.8601	3.7980	-.069032
91	3.5700	3.6253	.0338967	3.1605	4.0901	-.055345
92	3.6500	3.6833	.0362413	3.2178	4.1488	-.033303
93	3.3800	3.5996	.0427296	3.1320	4.0672	-.219633
94	3.7700	3.7622	.0395784	3.2956	4.2287	.007841
95	3.6600	3.6692	.0371454	3.2034	4.1350	-.009195
96	3.8800	3.5853	.0554519	3.1125	4.0580	.294700

97	3.8500	3.6492	.0232919	3.1869	4.1114	.200800
98	3.3600	3.6426	.0387464	3.1763	4.1089	-.282604
99	3.5200	3.6290	.0381399	3.1629	4.0951	-.109001
100	3.8000	3.4354	.0305340	2.9715	3.8993	.364600
101	3.3100	3.5648	.0330162	3.1002	4.0293	-.254782
102	3.5400	3.3159	.0412896	2.8488	3.7830	.224100
103	3.4900	3.4285	.0341978	2.9636	3.8933	.061537
104	3.4100	3.4585	.0355410	2.9933	3.9238	-.048523
105	3.7000	3.6546	.0268543	3.1916	4.1176	.045376
106	3.8000	3.6249	.0275688	3.1617	4.0880	.175100
107	3.9200	3.7704	.0349565	3.3053	4.2355	.149600
108	4.0000	3.6773	.0288179	3.2138	4.1408	.322700
109	3.7400	3.3801	.0385128	2.9139	3.8463	.359900
110	3.6000	3.5632	.0312684	3.0991	4.0273	.036810
111	3.4500	3.7632	.0397434	3.2966	4.2298	-.313214
112	3.6300	3.5495	.0388616	3.0832	4.0158	.080471
113	3.7200	3.6440	.0469170	3.1748	4.1131	.076019
114	3.5900	3.4377	.0417018	2.9705	3.9050	.152300
115	3.7600	3.7169	.0399279	3.2503	4.1836	.043075
116	3.8300	3.5930	.0195283	3.1314	4.0546	.237000
117	3.3600	3.2940	.0530422	2.8223	3.7657	.065985
118	3.6000	3.6791	.0306870	3.2152	4.1431	-.079132
119	3.7300	3.6823	.0261201	3.2194	4.1451	.047744
120	3.7300	3.7405	.0638382	3.2637	4.2173	-.010530
121	3.4900	3.3873	.0507375	2.9166	3.8580	.102700
122	3.0100	3.5146	.0283787	3.0513	3.9780	-.504635
123	3.8300	3.6561	.0254926	3.1934	4.1188	.173900
124	3.1700	3.4249	.0314280	2.9608	3.8890	-.254884
125	3.8800	3.5728	.0391772	3.1064	4.0392	.307200
126	3.6300	3.6794	.0357359	3.2140	4.1447	-.049372
127	3.5100	3.5531	.0322762	3.0888	4.0175	-.043144
128	3.4400	3.4616	.0346060	2.9966	3.9266	-.021575
129	3.4400	3.5038	.0545556	3.0315	3.9762	-.063825
130	3.7600	3.4364	.0463308	2.9675	3.9053	.323600
131	3.2500	3.5200	.0232488	3.0577	3.9822	-.269981
132	3.4900	3.5771	.0294841	3.1135	4.0408	-.087142
133	3.1200	3.4605	.0275611	2.9974	3.9237	-.340543
134	3.3700	3.3288	.0442638	2.8607	3.7970	.041179
135	3.3300	3.5805	.0215598	3.1186	4.0424	-.250496
136	3.3200	3.3749	.0377179	2.9090	3.8409	-.054950
137	3.9000	3.5356	.0304698	3.0717	3.9995	.364400
138	3.7800	3.5926	.0313631	3.1285	1.0567	.187400
139	3.8600	3.5586	.0246484	3.0961	4.0212	.301400
140	3.3900	3.5529	.0262342	3.0900	4.0158	-.162895
141	3.2400	3.3152	.0453953	2.8467	3.7838	-.075250
142	3.7500	3.5781	.0513535	3.1071	4.0490	.171900
143	3.7800	3.7104	.0329114	3.2459	4.1750	.069573
144	3.5100	3.5425	.0320992	3.0782	4.0068	-.032514
145	3.1700	3.5648	.0196540	3.1032	4.0264	-.394803
146	3.4700	3.6740	.0487735	3.2041	4.1439	-.204010
147	3.3900	3.6155	.0337191	3.1507	4.0802	-.225460
148	3.7200	3.4814	.0287494	3.0179	3.9448	.238600

149	3.3900	3.6270	.0233729	3.1647	4.0893	-.236994
150	3.5900	3.3640	.0397972	2.8974	3.8306	.226000
151	3.8300	3.6570	.0321179	3.1927	4.1213	.173000
152	3.7400	3.5421	.0223629	3.0800	4.0042	.197900
153	3.5800	3.5658	.0418966	3.0985	4.0331	.014230
154	4.0000	3.5773	.0241601	3.1149	4.0398	.422700
155	3.4800	3.5902	.0197913	3.1285	4.0518	-.110180
156	4.0000	3.6373	.0301097	3.1735	4.1011	.362700
157	3.6100	3.5039	.0374925	3.0381	3.9698	.106100
158	3.4200	3.4926	.0254147	3.0299	3.9553	-.072632
159	3.7100	3.5093	.0236577	3.0470	3.9717	.200700
160	3.4900	3.5535	.0200531	3.0918	4.0152	-.063526
161	3.5700	3.5261	.0206338	3.0644	3.9879	.043867
162	3.6100	3.6287	.0211252	3.1668	4.0906	-.018708
163	3.5600	3.3391	.0355519	2.8738	3.8043	.220900
164	3.9100	3.7810	.0479044	3.3114	4.2505	.129000
165	3.3600	3.3890	.0368834	2.9233	3.8547	-.028992
166	3.0600	3.4715	.0331539	3.0069	3.9360	-.411453
167	3.8900	3.6877	.0392671	3.2213	4.1541	.202300
168	3.4300	3.6563	.0302572	3.1924	4.1201	-.226271
169	3.2600	3.3606	.0330862	2.8960	3.8252	-.100582
170	2.6200	3.6155	.0304348	3.1517	4.0794	-.995530
171	3.4400	3.5920	.0323390	3.1277	4.0564	-.152037
172	4.0000	3.7715	.0340422	3.3067	4.2364	.228500
173	3.1100	3.4492	.0337828	2.9845	3.9140	-.339243
174	3.5000	3.3187	.0418205	2.8514	3.7860	.181300
175	3.2400	3.4246	.0291191	2.9611	3.8881	-.184604
176	3.7000	3.4894	.0301809	3.0256	3.9532	.210600
177	3.7000	3.6342	.0302008	3.1704	4.0980	.065814
178	3.4300	3.4099	.0320535	2.9456	3.8742	.020116
179	3.5900	3.5637	.0343137	3.0988	4.0286	.026295
180	3.5700	3.4727	.0423971	3.0052	3.9402	.097316
181	3.8000	3.5065	.0331003	3.0419	3.9711	.293500
182	3.1100	3.3902	.0349526	2.9251	3.8553	-.280188
183	3.4700	3.6002	.0272218	3.1371	4.0633	-.130188
184	3.7600	3.8011	.0406277	3.3342	4.2680	-.041075
185	3.6800	3.5965	.0237086	3.1341	4.0588	.083527
186	3.3000	3.5072	.0247298	3.0447	3.9698	-.207241
187	3.7500	3.7408	.0581792	3.2668	4.2148	.009199
188	3.9500	3.8206	.0358599	3.3552	4.2859	.129400
189	3.7300	3.5151	.0380983	3.0490	3.9812	.214900
190	3.4600	3.4408	.0541076	2.9687	3.9130	.019178
191	3.7100	3.5507	.0395738	3.0841	4.0172	.159300
192	3.7000	3.4950	.0301551	3.0312	3.9588	.205000
193	3.5200	3.5867	.0409182	3.1197	4.0537	-.066681
194	3.6100	3.6547	.0412190	3.1877	4.1218	-.044749
195	3.5700	3.5697	.0258819	3.1069	4.0325	2.6E-04
196	3.5000	3.6142	.0219422	3.1522	4.0762	-.114166
197	3.8400	3.8388	.0430134	3.3711	4.3065	.001157
198	3.5300	3.4413	.0371365	2.9755	3.9070	.088734
199	3.5500	3.5014	.0246562	3.0388	3.9639	.048613
200	3.9300	3.7684	.0449074	3.3000	4.2368	.161600

201	3.3300	3.4912	.0290878	3.0276	3.9547	-.161175
202	3.7900	3.5655	.0200411	3.1038	4.0272	.224500
203	3.7900	3.6219	.0392760	3.1555	4.0884	.168100
204	3.6400	3.6053	.0271853	3.1422	4.0684	.034679
205	3.4200	3.6292	.0291267	3.1656	4.0927	-.209189
206	3.4500	3.3219	.0396608	2.8553	3.7884	.128100
207	3.7200	3.7009	.0289955	3.2373	4.1644	.019145
208	3.6900	3.7375	.0280453	3.2742	4.2008	-.047509
209	3.7000	3.5985	.0332411	3.1339	4.0631	.101500
210	3.4300	3.5618	.0204853	3.1000	4.0235	-.131761
211	3.3700	3.4106	.0338698	2.9458	3.8754	-.040611
212	3.9300	3.7242	.0476145	3.2548	4.1936	.205800
213	3.6100	3.6750	.0346215	3.2100	4.1400	-.065023
214	3.7600	3.5656	.0366907	3.1000	4.0312	.194400
215	3.5400	3.5690	.0509571	3.0982	4.0398	-.028992
216	3.9700	3.8480	.0448023	3.3796	4.3163	.122000
217	3.9900	3.7162	.0248979	3.2536	4.1788	.273800
218	3.7900	3.8194	.0447401	3.3511	4.2878	-.029437
219	3.8800	3.4069	.0364189	2.9413	3.8724	.473100
220	3.0200	3.2545	.0448378	2.7861	3.7228	-.234467
221	4.0000	3.9454	.0481626	3.4758	4.4151	.054554
222	3.4900	3.4203	.0385997	2.9540	3.8865	.069742
223	3.2900	3.5988	.0364396	3.1333	4.0644	-.308814
224	3.6100	3.6140	.0423472	3.1466	4.0815	-.004041
225	3.3700	3.3744	.0387506	2.9082	3.8407	-.004449
226	3.2200	3.5504	.0385295	3.0842	4.0166	-.330422
227	3.3900	3.6790	.0349485	3.2139	4.1441	-.289016
228	3.4700	3.4884	.0393187	3.0219	3.9548	-.018360
229	3.8900	3.7987	.0367804	3.3331	4.2644	.091251
230	3.7300	3.7235	.0379592	3.2575	4.1895	.006512
231	3.4500	3.4886	.0248280	3.0260	3.9512	-.038613
232	3.5600	3.5874	.0384332	3.1213	4.0536	-.027423
233	3.5700	3.7830	.0420241	3.3156	4.2503	-.212991
234	3.5600	3.7382	.0327985	3.2737	4.2027	-.178195
235	3.7400	3.6771	.0415793	3.2099	4.1443	.062892
236	3.8300	3.6526	.0372830	3.1868	4.1184	.177400
237	3.3900	3.5928	.0210994	3.1310	4.0547	-.202837
238	3.6400	3.6623	.0404901	3.1955	4.1291	-.022300
239	3.1700	3.4857	.0410304	3.0187	3.9527	-.315723
240	3.1200	3.5201	.0524751	3.0487	3.9916	-.400142
241	3.0300	3.2201	.0493119	2.7500	3.6902	-.190114
242	3.5900	3.5106	.0276077	3.0474	3.9738	.079377
243	2.9000	3.3195	.0569705	2.8461	3.7930	-.419527
244	3.5600	3.4898	.0299595	3.0261	3.9536	.070158
245	3.9400	3.6251	.0364178	3.1596	4.0906	.314900
246	3.7800	3.5880	.0341046	3.1231	4.0528	.192000
247	3.2200	3.7285	.0387519	3.2622	4.1948	-.508497
248	3.3800	3.6400	.0219841	3.1780	4.1020	-.259986
249	3.2000	3.6137	.0352555	3.1485	4.0789	-.413700
250	3.5900	3.4789	.0298227	3.0152	3.9426	.111100
251	4.0000	3.8249	.0442313	3.3568	4.2931	.175100
252	3.5100	3.6152	.0314872	3.1510	4.0793	-.105192

253	3.8900	3.6389	.0218752	3.1769	4.1009	.251100
254	3.3600	3.3003	.0417727	2.8330	3.7675	.059749
255	3.6400	3.6034	.0400526	3.1367	4.0701	.036606
256	3.6600	3.4143	.0390699	2.9479	3.8806	.245700
257	3.5200	3.3292	.0596212	2.8545	3.8039	.190800
258	3.8900	3.6439	.0270411	3.1809	4.1070	.246100
259	3.7400	3.6943	.0357597	3.2290	4.1597	.045675
260	3.4200	3.3585	.0400384	2.8918	3.8251	.061539
261	3.6400	3.4942	.0308286	3.0302	3.9581	.145800
262	3.2400	3.7856	.0581983	3.3116	4.2597	-.545640
263	3.5900	3.4383	.0293123	2.9747	3.9019	.151700
264	3.4900	3.4212	.0448710	2.9528	3.8896	.068807
265	3.3100	3.4975	.0383504	3.0313	3.9636	-.187469
266	3.4700	3.5555	.0370990	3.0898	4.0212	-.085500
267	3.5500	3.5307	.0300133	3.0669	3.9944	.019346
268	3.7900	3.7272	.0318596	3.2630	4.1915	.062751
269	3.9300	3.7446	.0329561	3.2801	4.2092	.185400
270	4.0000	3.7112	.0313628	3.2471	4.1753	.288800
271	3.7400	3.6112	.0356710	3.1459	4.0765	.128800
272	3.6000	3.5897	.0440795	3.1216	4.0578	.010310
273	3.6100	3.5301	.0354014	3.0648	3.9953	.079936
274	3.6000	3.6335	.0297250	3.1698	4.0972	-.033514
275	3.4100	3.5771	.0258075	3.1143	4.0399	-.167115
276	3.7600	3.7458	.0298201	3.2820	4.2095	.014246
277	3.5000	3.5707	.0403242	3.1039	4.0375	-.070675
278	3.0900	3.6294	.0297034	3.1657	4.0931	-.539438
279	3.6100	3.6527	.0307124	3.1888	4.1166	-.042697
280	3.9300	3.7703	.0556516	3.2975	4.2431	.159700
281	3.2400	3.5091	.0256691	3.0463	3.9718	-.269081
282	3.7900	3.6486	.0237989	3.1862	4.1109	.141400
283	3.1000	3.3534	.0385644	2.8872	3.8196	-.253405
284	3.5400	3.5114	.0480755	3.0418	3.9811	.028552
285	3.7200	3.5399	.0300917	3.0761	4.0037	.180100
286	3.6900	3.6686	.0284879	3.2052	4.1319	.021444
287	3.3900	3.6569	.0235309	3.1946	4.1192	-.266902
288	3.7200	3.5608	.0343753	3.0959	4.0257	.159200
289	3.3500	3.4868	.0296774	3.0231	3.9504	-.136766
290	3.5500	3.4282	.0340178	2.9634	3.8931	.121800
291	4.0000	3.6804	.0317449	3.2161	4.1446	.319600
292	3.8400	3.7363	.0328685	3.2718	4.2008	.103700
293	3.6200	3.5333	.0256561	3.0705	3.9960	.086744
294	3.1100	3.4764	.0387918	3.0101	3.9426	-.366359
295	3.5000	3.5140	.0284327	3.0506	3.9774	-.013989
296	3.7100	3.6166	.0383018	3.1505	4.0827	.093383
297	3.1500	3.3537	.0359849	2.8683	3.8191	-.203693
298	3.6000	3.4577	.0395886	2.9912	3.9242	.142300
299	3.8800	3.4998	.0381741	3.0337	3.9659	.380200
300	3.4900	3.4790	.0235687	3.0167	3.9413	.011006
301	3.0400	3.3241	.0436457	2.8561	3.7920	-.284071
302	2.7200	3.5534	.0255316	3.0907	4.0161	-.833378
303	3.8300	3.5088	.0351382	3.0436	3.9739	.321200
304	3.5600	3.5629	.0197071	3.1013	4.0245	-.002924

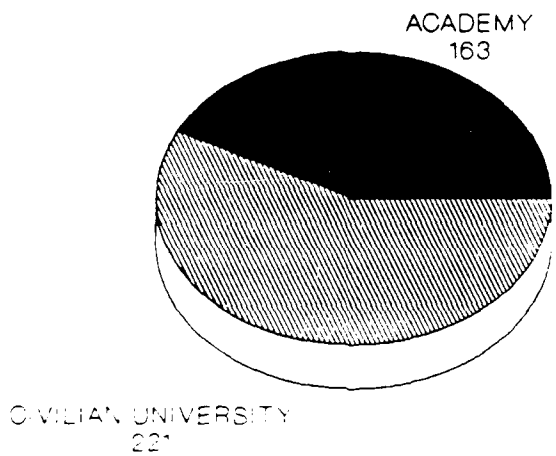
305	3.9400	3.4969	.0328275	3.0324	3.9614	.443100
306	3.7800	3.4362	.0394784	2.9697	3.9027	.343800
307	4.0000	3.7182	.0574308	3.2446	4.1919	.281800
308	3.5100	3.6149	.0279123	3.1516	4.0781	-.104885
309	3.2800	3.6035	.0345796	3.1385	4.0685	-.323539
310	3.8300	3.7027	.0276371	3.2395	4.1659	.127300
311	3.6200	3.5216	.0230207	3.0594	3.9838	.098395
312	3.5100	3.5560	.0284147	3.0926	4.0194	-.045985
313	3.8800	3.5197	.0326211	3.0552	3.9841	.360300
314	3.9600	3.7681	.0321484	3.3038	4.2324	.191900
315	3.7300	3.6700	.0395938	3.2035	4.1366	.059965
316	3.5400	3.5815	.0368487	3.1159	4.0472	-.041549
317	3.5300	3.8619	.0426805	3.3943	4.3295	-.331868
318	3.6900	3.4985	.0488791	3.0286	3.9684	.191500
319	3.9700	3.5565	.0334604	3.0918	4.0212	.413500
320	3.6100	3.6861	.0238447	3.2238	4.1485	-.076142
321	3.6900	3.3966	.0301718	2.9328	3.8604	.293400
322	3.4000	3.5259	.0282017	3.0626	3.9892	-.125913
323	3.6200	3.5320	.0333043	3.0673	3.9966	.088026
324	3.0300	3.5917	.0299160	3.1280	4.0554	-.561697
325	3.5400	3.7189	.0330060	3.2544	4.1835	-.178905
326	3.8300	3.6307	.0307411	3.1667	4.0946	.199300
327	3.4700	3.5749	.0335809	3.1102	4.0396	-.104893
328	3.9300	3.7155	.0266348	3.2525	4.1784	.214500
329	4.0000	3.7817	.0538099	3.3097	4.2537	.218300
330	3.3600	3.5719	.0359329	3.1065	4.0372	-.211853
331	3.6600	3.7172	.0283014	3.2538	4.1805	-.057192
332	3.2800	3.3425	.0351122	2.8774	3.8077	-.062545
333	3.9300	3.6605	.0222643	3.1984	4.1226	.269500
334	3.5800	3.6004	.0212148	3.1385	4.0623	-.020419
335	3.7600	3.6036	.0310866	3.1396	4.0677	.156400
336	3.9600	3.6934	.0347729	3.2283	4.1584	.266600
337	3.4000	3.3761	.0396044	2.9096	3.8427	.023863
338	3.8200	3.7723	.0341064	3.3074	4.2371	.047728
339	3.0200	3.3871	.0370392	2.9214	3.8528	-.367113
340	3.8200	3.6365	.0314963	3.1723	4.1006	.183500
341	3.0000	3.5949	.0195650	3.1333	4.0565	-.594876
342	3.3000	3.4605	.0306935	2.9965	3.9244	-.160486
343	3.8200	3.6430	.0276849	3.1798	4.1062	.177000
344	4.0000	3.5635	.0286221	3.1001	4.0269	.436500
345	2.9400	3.5197	.0222992	3.0576	3.9818	-.579694
346	3.8000	3.6688	.0427211	3.2012	4.1364	.131200
347	3.7700	3.5681	.0240393	3.1057	4.0305	.201900
348	3.5800	3.4792	.0240609	3.0167	3.9416	.100800
349	3.9200	3.4844	.0316395	3.0202	3.9486	.435600
350	3.8200	3.6099	.030611	3.1460	4.0738	.210100
351	4.0000	3.7849	.0345363	3.3199	4.2499	.215100
352	4.0000	3.7733	.0388999	3.3070	4.2396	.226700
353	3.0500	3.6168	.0318048	3.1526	4.0810	-.566788
354	3.1500	3.4773	.0440082	3.0092	3.9453	-.327258
355	3.1900	3.5446	.0306433	3.0806	4.0085	-.354568
356	3.3800	3.5643	.0326085	3.0999	4.0288	-.184343

357	3.6800	3.5868	.0466477	3.1178	4.0559	.093175
358	3.7200	3.3436	.0408875	2.8766	3.8105	.376400
359	3.4000	3.6001	.0307459	3.1362	4.0641	-.200141
360	3.7300	3.5625	.0445922	3.0942	4.0308	.167500
361	3.8600	3.6062	.0264792	3.1433	4.0692	.253800
362	4.0000	3.7233	.0280457	3.2600	4.1866	.276700
363	3.2400	3.4453	.0276443	2.9821	3.9085	-.205337
364	3.4700	3.5558	.0334391	3.0911	4.0204	-.085762
365	3.6900	3.5624	.0404364	3.0956	4.0292	.127600
366	3.8900	3.6905	.0442341	3.2223	4.1586	.199500
367	3.9600	3.6566	.032059	3.1923	4.1209	.303400
368	2.9600	3.6607	.0239118	3.1983	4.1231	-.700661
369	3.5400	3.6032	.0212224	3.1413	4.0651	-.063197
370	3.2800	3.5446	.0427355	3.0770	4.0122	-.264605
371	3.7800	3.7134	.0377079	3.2474	4.1793	.066623
372	3.7000	3.6100	.0359906	3.1446	4.0754	.089979
373	3.8800	3.8138	.0427278	3.3461	4.2814	.066250
374	3.7100	3.5922	.025616	3.1294	4.0549	.117800
375	3.3600	3.5010	.0396848	3.0344	3.9675	-.140969
376	4.0000	3.5446	.0200764	3.0829	4.0063	.455400
377	4.0000	3.6472	.0307244	3.1832	4.1111	.352800
378	3.4800	3.5697	.0275214	3.1066	4.0329	-.089736
379	3.8100	3.7034	.0275562	3.2402	4.1666	.106600
380	2.9800	3.4131	.0350662	2.9479	3.8782	-.433071
381	3.8200	3.4142	.0361058	2.9487	3.8796	.405800
382	3.0300	3.5366	.0209945	3.0748	3.9985	-.506610
383	3.1700	3.7987	.0419378	3.3314	4.2660	-.628714
384	3.8100	3.6055	.0332595	3.1408	4.0701	.204500

SUM OF RESIDUALS = -1.97953E-13
SUM OF SQUARED RESIDUALS = 20.52203
AVERAGE ABSOLUTE ERROR OF PREDICTION = 0.2311769

APPENDIX K: DEMOGRAPHIC INFORMATION

UNDERGRADUATE INSTITUTIONS



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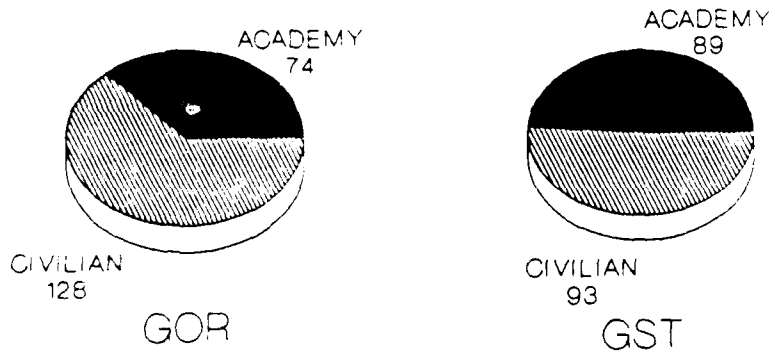
UNDERGRADUATE INSTITUTIONS
(by program)



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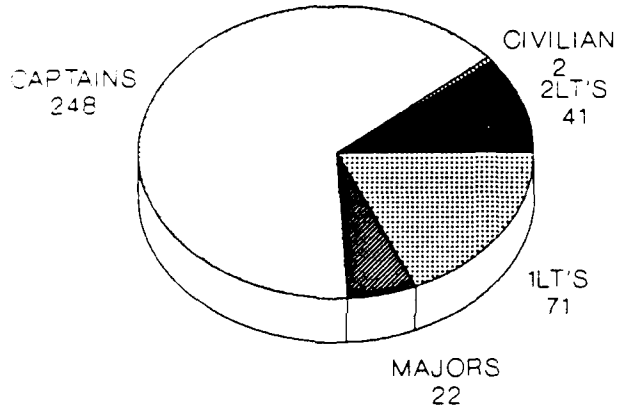
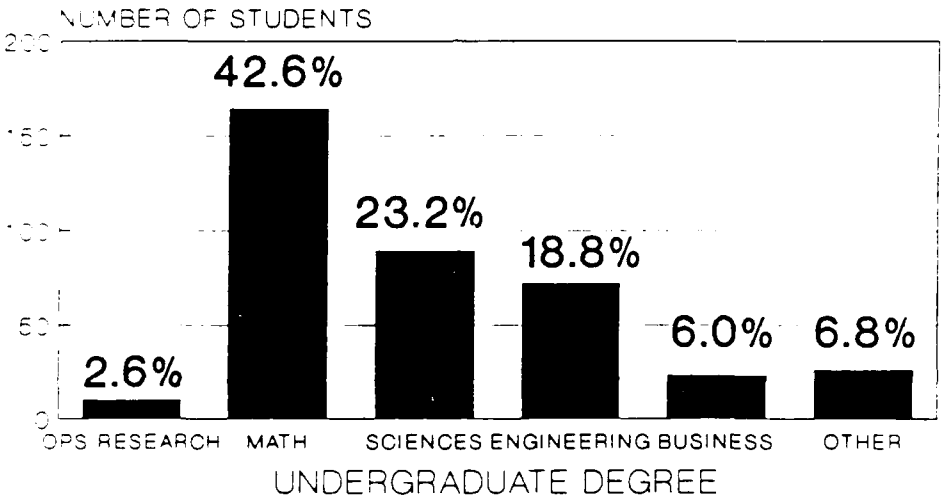
STUDENT RANKS
(GOR'S & GST COMBINED)



n = 384

APPENDIX L: Undergraduate Degrees



APPENDIX M: LIST OF ABBREVIATIONS

AFIT	-	United States Air Force Institute of Technology
AFMPC	-	United States Air Force Military Personnel Center
AFSC	-	Air Force Specialty Code
AR	-	Aeronautical Rating
DEG	-	Type of Undergraduate Degree
DOD	-	United States Department of Defense
GGPA	-	Graduate Grade Point Average
GMAT	-	Graduate Management Admission Test
GOR	-	Graduate Program in Operations Research (used in this study to refer to both the program and a student enrolled in the program)
GPA	-	Grade Point Average (also used to refer to both the GOR and GST classes combined
GRE	-	Graduate Records Examination
GRE-A	-	Graduate Records Examination (Analytic)
GRE-Q	-	Graduate Records Examination (Quantitative)
GRE-T	-	Graduate Records Examination (Total Score)
GRE-V	-	Graduate Records Examination (Verbal)
GST	-	Graduate Program in Strategic and Tactical Sciences (used in this study to refer to both the program and a student enrolled in the program)
MS	-	Martial Status
OER	-	Officer Efficiency Reports
PG	-	Previous Graduate Degree
QS	-	Quality of Schools Factor
SC	-	Student Code

S1 - Success level 1 ($4.0 \leq GGPA \leq 3.67$)

S2 - Success level 2 ($3.66 \leq GGPA \leq 3.33$)

S3 - Success level 3 ($3.32 \leq GGPA$)

TD - Time since Degree

TM - Time in Military

UGPA - Undergraduate Grade Point Average

UGPA - Undergraduate Grade Point Average

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VITA

Captain William N. Prokopyk [redacted] PII Redacted [redacted] He graduated from Chaney High School in 1975 and attended Youngstown State University, from which he received the degree of Bachelor of Applied Arts and Sciences in Civil Engineering Technology in 1979. He was commissioned as a Distinguished Military Graduate into the United States Army Corps of Engineers as a second lieutenant in 1979. He has served as an Engineer Platoon Leader and Company Executive Officer in the 62d Engineer Battalion (Combat) (Heavy), Fort Hood, Texas from 1979 to 1982. After attendance at the Engineer Officer Advanced Course at Fort Belvoir, Virginia, he served at Fort Bragg, North Carolina from 1983 to 1986. At Fort Bragg, Captain Prokopyk was assigned as the 20th Engineer Brigade's (Combat) (Airborne) Training Officer, the Commander of the 618th Engineer Company, (Light Equipment) (Airborne), and as an Assistant Inspector General with XVIII Airborne Corps until entering the School of Engineering, Air Force Institute of Technology, in August 1986.

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The purpose of this study was to examine those measureable factors which contribute to Grade Point Performance in the Air Force Institute of Technology's Graduate Operations Research Programs. Student's undergraduate grade point averages and other performance indicators which could be quantified were submitted to statistical analysis. Regression models were then built to illustrate the relationships between the performance indicators and Graduate Grade Point Average.

Some of the predictors were Graduate Records Examination scores, Undergraduate grade point averages, undergraduate institution, and martial status.

This study showed that Graduate Grade Point Average cannot be predicted with any great degree of accuracy. There are many factors contributing to human behavior and performance. This study began to identify those measurable factors which contribute to the prediction equations which provide an indication of those variables which contribute to academic performance.

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